BUSH VITALITY ASSESSMENT

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ASSESSMENT

GROWING COMMON FUTURES

HELMUT J. JANSSEN

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Figure 1: (overleaf): An insightful outlook – Manawatu Gorge, Tararua.
Photo: Helmut Janssen

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Foreword

Life is the greatest gift…
…to be enjoyed and looked after.

Bush Vitality Assessment has been prepared to help people care for and manage native forest remnants on private land. Our forest remnants, or bush patches, are an essential part of our landscape and are also important in ensuring the survival of our unique native plants and animals.

This book brings together a wealth of science and practical knowledge to help landowners, and those with an interest in nearby bush patches, to determine quickly and easily the ecological health of these bush patches. The bush vitality assessment that forms the first part describes what to look for and why, and how to interpret what you see in the bush.

But knowing the state of bush health is not enough, so the second part gives guidance on how to improve bush health. It provides simple robust tools to assess ecosystem resilience and assist landowners to implement wise and sustainable land management practices. This helps landowners create bush patches that will be vibrant in five, ten, and more years, and remain a vital part of our landscape.

Within the first year of publication, the approaches set out in the first edition of this book were taken up by many people, keen to 'give it a go'.

This revised edition expands on a number of points, particularly the native afforestation chapter. There is a keen and growing interest from iwi, Federated Farmers, QE2 and local government to implement sustainable native afforestation programmes. All realise the sustainable development potential of growing native trees to generate genuine capital value for future generations, to optimise the land's sustainable productivity, to re-associate tangata whenua with their land, and to restore bush vitality.

Nau te rau rau	With your strand
Naku te rau rau	and my strand
Ka ki te kete	we weave (together)
	a basket (of knowledge)

Acknowledgements

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I thank my family and friends, in particular my children Ace and Rata and my parents Anneliese and Jack Janssen, for sharing my love and respect for life and the natural world, for foresight and dedication to achieve a sustainable way of life.

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Please visit www.bushvitality.org.nz
and www.landcare.org.nz to:

- Help you assess your bush remnant's vitality,
- Develop your bush-restoration, sustainable farming strategy,
- View related projects and relevant contacts
- Exchange information about Bush Vitality Assessment/Restoration and Native Afforestation projects in other parts of the country.
- Grow Common Futures.

Introduction

Has the future of your local native bush patch concerned you, as you observed exotic pests gaining a foothold over the years and can only remember the birds that once were heard?

The bush is like a human being – a living, breathing system, just like the rest of us trying to make a living and raise a family. And like humans, when a piece of bush has been knocked around, cut down to size and not looked after, it loses vitality as pests and diseases invade.

A healthy bush is bursting with life. It will have a continuous canopy, perhaps with tall emergent trees above, their sturdy branches supporting lofty gardens for birds and insects alike. Each storey provides food and shelter to adapted birds, reptiles and invertebrates.

Amongst the shade-tolerant subcanopy and understorey plants, the forest giants' next generation grows. Their ancestors often support these juveniles, as seedlings begin their life on tree trunks and fungi help transfer the previous generation's nutrient stores. Shade-tolerant mosses, ferns, shrubs and subcanopy trees share this forest nursery, providing homes and rich resources for native birds and invertebrates.

Just as all animals ultimately rely on plants for their food, many plants rely on insects, lizards and birds for pollination and seed dispersal.

Forest streams and wetlands provide dynamic habitats and natural corridors, places of rapid growth, opportunity and migration for native plants and animals alike.

A bush patch is part of a mosaic of other bush types up and down the catchment that together provide continuous, year-round food and shelter for native animals. Just as importantly, it gives us a place to go for peace and recreation, while giving our property, and land its unique identity.

Unfortunately, many bush patches are not healthy. They are already only remnants of once much larger and mightier forests that covered the country's lowlands and hills over 100 years ago. Many now support only a few of the plants, trees and birds common in earlier times. Their small size, stock undergrazing, and invasion by plant and animal pests means many patches are at risk of losing more native species unless action is taken soon. People often fail to notice such continuing decline, unless observant elders share their impressions with the younger generation.

People want to look after the bush patches on their land, or nearby, and want to do the right thing. But they do not always know what the right thing is, or even that the bush is at risk in the first place. With guidance, symptoms can be diagnosed and the causes of the disease understood and a recovery plan developed. This kit helps you examine the vital parts of the patch of bush near you. It shows you how to take the pulse, diagnose the disease, get a prescription and develop and implement a recovery plan to restore resilience to your bush patch long-term.

Importantly, you are not alone! Bush owners throughout New Zealand want to do the right thing and, like you, are prepared to act. QEII Trust, Regional Councils and the Department of Conservation (DoC) will be pleased to assist you with this task, by giving practical advice, providing financial incentives and helping to implement your management priorities. Comprehensive biodiversity inventories identify 'key native ecosystems'. Consistent monitoring programmes will track native biodiversity trends. Ecological research and 'adaptive management' projects deliver relevant and practical information to all stakeholders. Together we can make a difference and bring back the dawn chorus.

New Zealand native forest is unique. Of the 2,500 trees, shrubs and grasses that are known in this country, over 80% are only found in New Zealand. New Zealand is internationally recognised as one of the richest and most threatened reservoirs of plant and animal life on Earth (www.biodiversityhotspots.org). Today, some 2,400 native plants and animals are under threat. The State of New Zealand's Environment Report, published in 1997, concluded that decline in native biological diversity is the most pervasive environmental issue in New Zealand.

The change from a predominantly native ecosystem to a predominantly cleared exotic landscape has occurred relatively recently. Most fertile and productive lowland forest ecosystems and wetlands (80% to over 95%) were replaced over the past 150 years. This recent shift accounts for particular pressures on the fate of remaining native animal and plant populations in isolated bush remnants, many of which face extinction unless steps are undertaken to restore bush patch resilience.

Resilience of isolated native bush remnants is often low, as essential ecological processes may not operate as they should, particularly where native key species[1] have become locally extinct.

Ecosystem processes[2] refer to evolved functional links[3] and symbioses[4] that are a feature of native ecosystems. Weakened ecological processes affect the ongoing survival of a site's native plant and animal populations with each loss contributing to the decline of native biodiversity.

This Bush Vitality Assessment Kit helps people understand threats to native ecological processes that affect the vitality of the assessed native bush remnant.

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1 Keystone species are found in plants, insects, fungi, and birds. They have a prominent role, often as symbiotic organisms, in sustaining ecosystem processes (refer to next footnotes).

2 Food webs (of producers, consumers and decomposers), symbioses (particularly between keystone species) and regeneration characterise the ecological processes of a particular ecosystem.

3 Between complex webs of site adapted organisms that efficiently cycle and conserve energy and nutrients, which define a native ecosystem and sustain its resilience.

4 Symbiosis refers to dissimilar organisms mutually benefiting each other (fruiting plants and seed-distributing birds; nutrient exchange between plants and fungi).

This understanding is essential to:
1. effectively restore native bush resilience long-term and
2. efficiently maintain native biodiversity.

Native bush resilience

The Bush Vitality Kit focuses on a few key bird and plant species. Other species are important too, but those selected for this kit are the key to bush remnant survival. Over two-thirds of New Zealand's lowland forest plants rely on native birds and insects for their propagation, while the birds rely on fruit, nectar and insects for food. Birds need a range of different plants to help them get through each year; plants need birds to ensure they survive the years.

Both plants and birds need enough habitat space to support viable populations, either by having large enough bush patches, or 'virtual space' corridors that allow migration between bush patches. Key bird and plant presence is used to measure the overall bush vitality – how well the bush can cope now and in the future. The kit also identifies threats to these plants and animals from stock and pests.

In this guide, you score your site's functional elements, which helps you assess its strengths and weaknesses, and develop a management plan to restore resilience to your native bush patch.

The plight of native birds

Many native birds, having evolved in forests, dislike open ground. For example, research shows female bellbirds remain within five kilometres of their forest home, limiting their potential to re-inhabit more isolated bush patches. About one hectare of interior bush can sustain one breeding bellbird pair, but a viable population needs a forest network of at least 20 hectares. Survival of native birds in your bush patch depends on reliable food sources, particularly during winter. Reliable winter food supplies are most common in native lowland bush, hence its importance.

Diversity of fruiting plants provides security in lean years. Bumper fruit crops in a few plant species (kahikatea, rimu, totara) are often followed by one or several lean fruiting years. Accessible and consistent food supplies from a variety of plant species (often subcanopy and shrub plants) are then critical in sustaining local bird populations.

The plight of native plants

New Zealand's bush contains many plants where male and female are separate plants (dioecy), rather than united in flowers on a single plant (as in apple, kowhai or kanuka). Our tall native conifers – the totara, kahikatea, miro, matai and rimu – are all either male or female trees. It is easy to see that procreation is affected where just a few trees are left in an isolated bush patch – they may not have a mate! Pollen cones reveal male trees (see Figures 2-5); seeds on fruit flesh reveal female trees.

These bush patches may also contain the last surviving adult specimens of a long lineage that, over many generations, had adapted to the localised environmental conditions in your area. Maintaining this genetic biodiversity, which improves a species' overall chances of survival, is the reasoning behind locally-sourcing plant material for restoration plantings.

Figure 2: Mature cone of a male miro tree. ♂

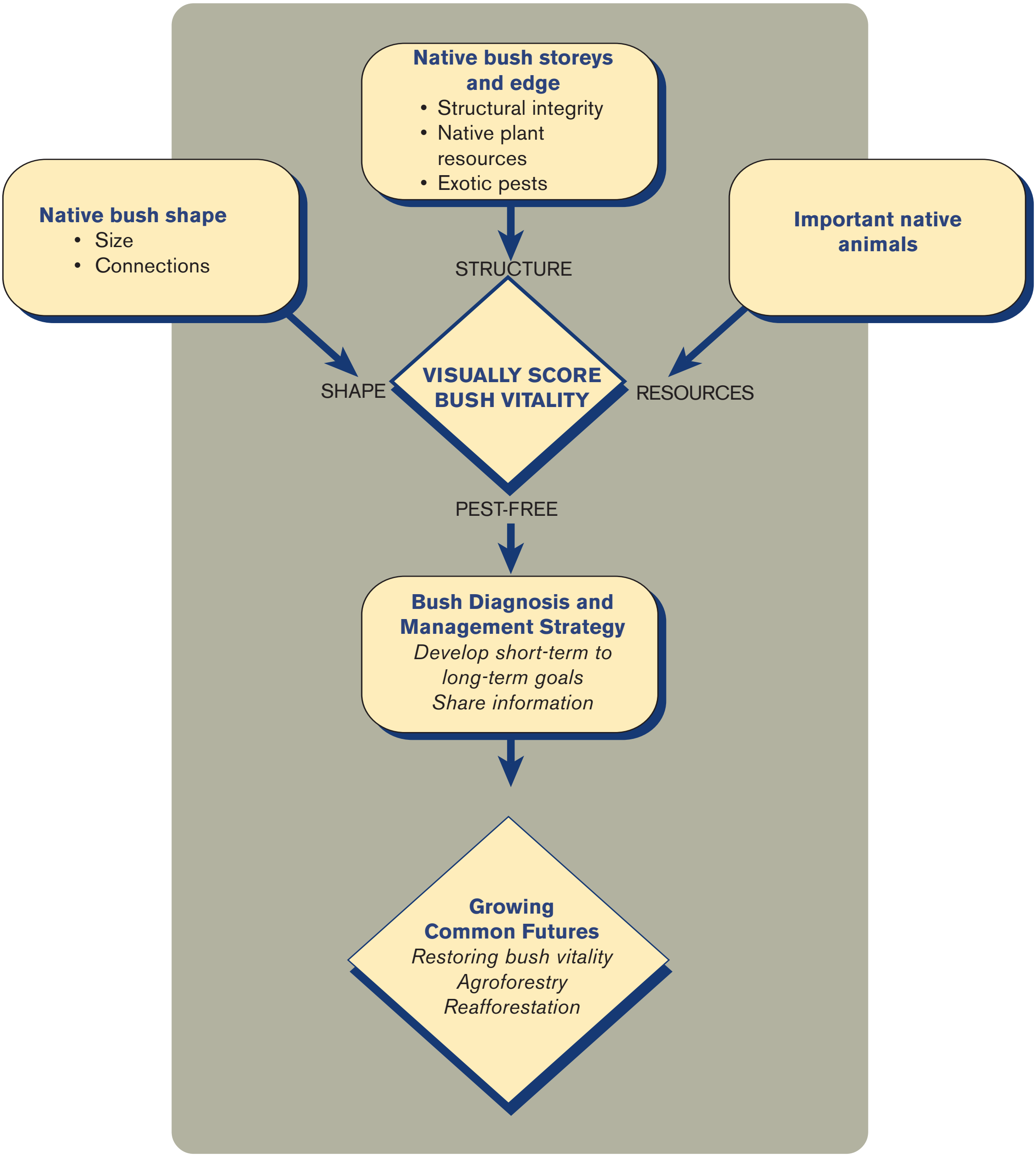
Figure 3: Mature seed of a female miro tree. ♀

Figure 4: Young rimu cones. ♂

Figure 5: Mature rimu cones. ♂

D Merton. DOC

Figure 6: The overall process of a bush vitality assessment.



How to use the kit

The kit is in two parts. Part 1 is a visual bush score, where you go into the bush to score your bush vitality. You then use these data to make a bush diagnosis, identifying its character and its management needs. In Part 2 you then develop a management strategy for the bush patch.

The vitality score is first. It has three integrated categories, each representing an important bush function. You need to look at:

1. the bush size, shape and how close it is to other native bush
2. the bush vegetation, identifying important plants within the different bush layers or storeys, and
3. any native birds and other important animals living in the bush.

This will give you the information to score your bush vitality, which then lets you make the bush diagnosis and develop a management strategy.

WHAT TO TAKE

Along with the **booklet** and **score sheet** take a **pencil** and perhaps a **clipboard**. A **topographic map** is useful, too. If you are assessing large bush patch, a **compass** and **copy of an aerial photo** of the bush you're scoring can be a great help, as you can use them to draw your observation transects. Visit the Regional Council website or pick up a photocopy at the Council office. You may want to check the length of transects in the field with a stride counter.

A **camera** and **binoculars** may be useful if you want to record something of interest or take a closer look at things. If you are going to **take a photo** of something that you will want to compare at a later date, make sure there is something distinguishing in the photo, a landmark, or use a utensil to show differences in abundance or height.

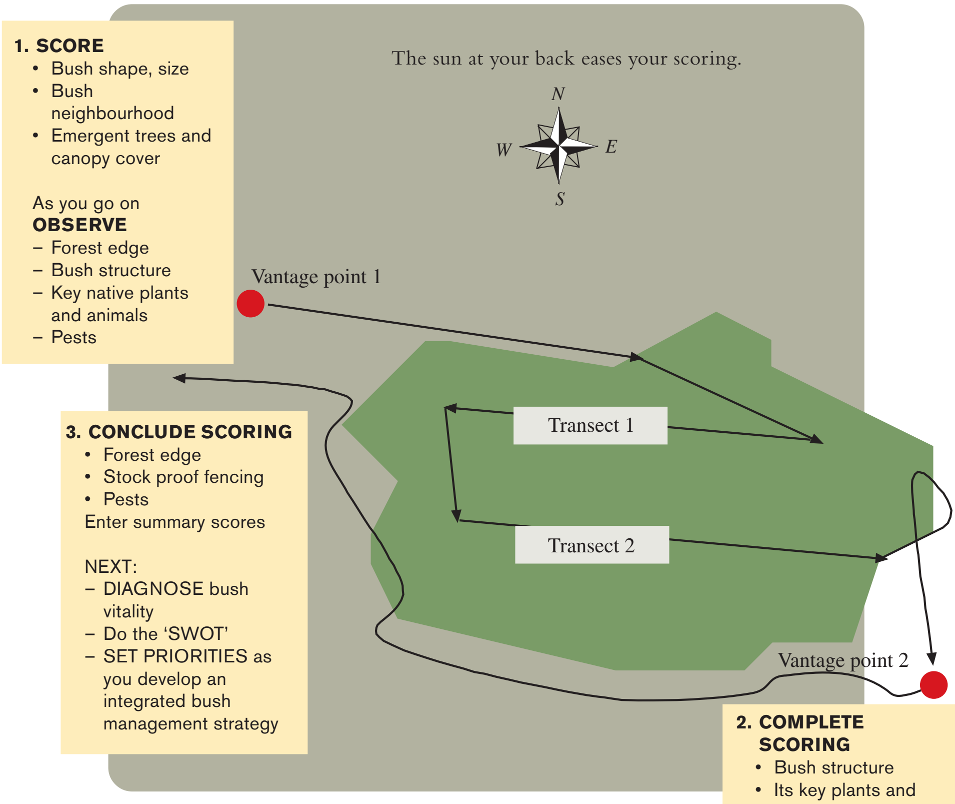
Remember **basic bush safety**; let someone know where you are going and take appropriate clothing and food.

Visual Bush Score

This part is the fieldwork. It is quite simple – it is just a slow and pleasant walk through the bush, making observations about what is in the bush patch, guided by the photos and score sheets provided.

Vantage points are useful for collecting your first lot of scores on your bush shape, certain native birds (tui and kereru), plant pests, cover and composition proportions of emergent and canopy storeys as well as the forest edge. Topo-maps can help you find good vantage points, such as hilltops or prominent bush angles. Figure 7 shows you an example of how you should plan your approach and a typical sequence of scoring

Figure 7: Sequence of visual bush scoring in the field.



If the bush patch is small, less than 5 hectares, you will need to cover enough ground to assign a score to each section with confidence. For larger bush patches (more than 5 hectares), you need a topographic map. Identify bush access-points, then draw up to 5 transect lines (each about 100m long) randomly through the bush patch. Locate those transect lines in the bush, then walk along them to make your observations. Doing this will give you a reasonable sub-sample to score larger bush patches with confidence, once you aggregate the scores for each transect.

Compare your observations with the photos of each section and score the bush. You may want to score your patch of bush between the given rankings (for example: you may give a score of 5 (see Table 19, A3 page 177) to a small native bush with varying width). Your observation and scoring skills will improve with each assessment you make.

Each scored section gets you closer to a good diagnosis. While the combined scores will rank the overall health and resilience of the bush, each score helps you to identify threats, opportunities and management options.

PART 1: VISUAL BUSH SCORE

Native bush patches

The Living Forests of New Zealand, NZ Native Forests Restoration Trust

Size and shape

Background

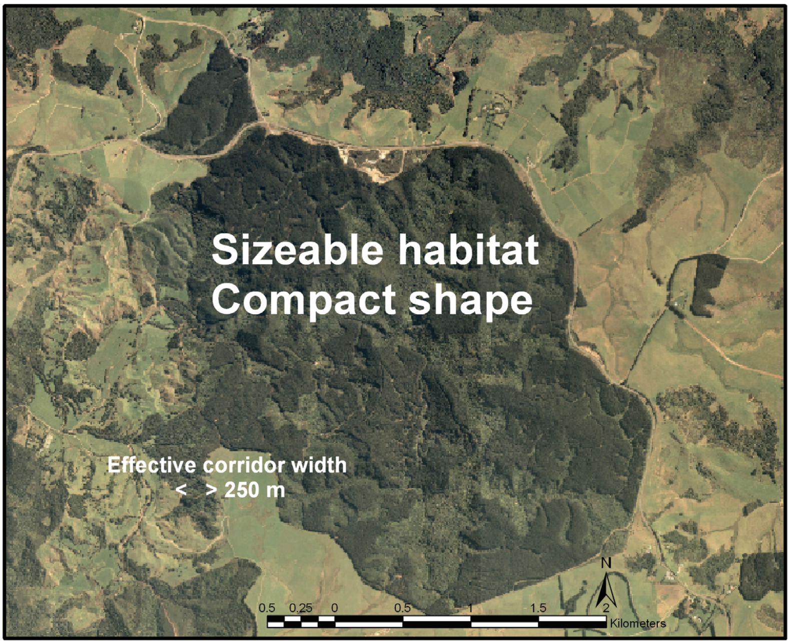
When it comes to the bush, big and compact is beautiful. A bush patch consists of bush interior and a surrounding zone of forest edge. The forest edge zone is 20–100m wide depending on aspect and exposure. The bigger and rounder a patch of bush is, the more 'interior space' it has. For example, a near-circular bush remnant of 5ha may only have about 1ha of interior habitat, whereas a 50ha bush can have up to 25ha of interior habitat. Most native plants and animals prefer the bush interior.

A single hectare of interior forest provides temporary seasonal and breeding habitat, providing an important stepping-stone for connecting isolated bird populations. Native forest networks of 25ha are generally large enough to sustain populations of native keystone species and thereby ecosystem functions, as long as pests are controlled.

SIZE CATEGORIES: HOW BIG?

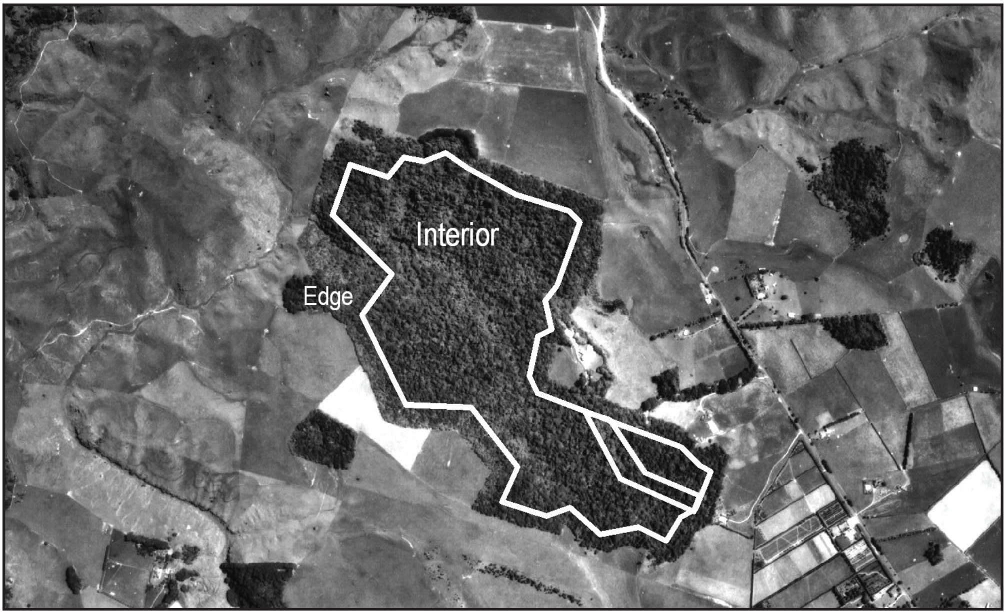
25 hectares are equivalent to a 500m square or one quarter of the blue 1km^2 grid on 1:50,000 scale topographic map. Five hectares are equivalent to a 225m square. 1 hectare = $(100m)^2$.

Figure 8: Good compact bush shape and good corridor width (Far North District). HJ



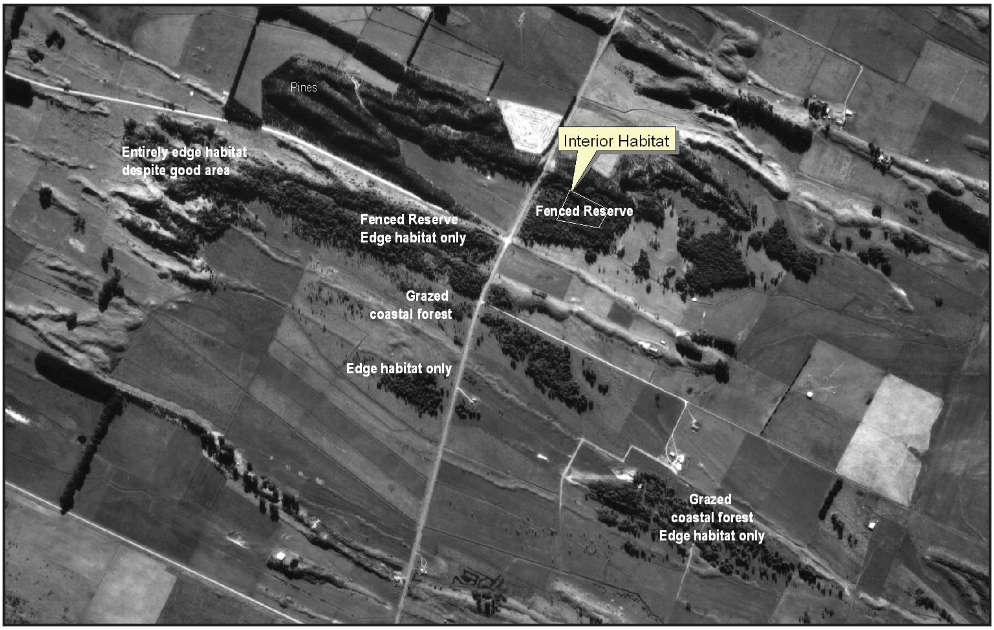
(Criterion score 16, Table 19, A1: page 177)

Figure 9: Medium size bush and good interior habitat size. Access road compromises interior habitat size. Big Bush Forest and Bird Reserve (Wanganui District). HJ



(Criterion score 10, Table 19, A2: page 177)

Figure 10: Poor shape and insufficient interior habitat space. Himatangi Scientific Reserve, degrading grazed bush remnants and pine forest (Horowhenua District). HJ



(Criterion score 6, Table 19, A3: page 177)

Elongated native bush shapes usually follow river valleys, escarpments or property boundaries and may have more edge and less interior habitat. Nevertheless such bush shapes usually form critical linkages between isolated native bush patches and can be an integral part of a viable network of native bush remnants. Corridors that are more than 100m wide contain interior habitat space. They more effectively link native populations and can be managed for multiple uses and require less maintenance.

With this assessment you are in fact scoring the ecological values of interior habitat and corridor effectiveness or potential.

Scoring

Start your assessment from a high vantage point and look down on the bush patch, where possible. Differentiate average bush widths within 3 size classes (from under 5 hectares to over 25 hectares). If you are assessing a large forest use a topo-map or a copy of an aerial photo, which may also be necessary to score bush connectivity in the next section.

Figure 11: Different forest habitats define shapes and sizes here. HJ

Native habitat connections

Background

Good bush connectivity improves food source availability, mating opportunities and allows pollen and seed interchange between bush remnants. The closer other bush patches are, the better their connectivity.

If another bush patch is within calling distance (less than 2km away), native birds are more likely to fly between them, accessing the wider range of food resources and dispersing native plants to new habitats. Well-connected bush fragments are important during the breeding season and to sustain local populations throughout the year.

Forests more than 5km away are less likely to be reached by the smaller native birds, so plant and bird populations remain fairly isolated from each other (Figure 12).

Broad riparian or streamside corridors enhance connectivity between distant bush patches (Figure 13). The connectedness of many healthy native bush patches can restore native ecosystem processes and their long-term resilience. Compatible exotic species (see examples in Table 14, pages 143 to 146) can enhance native bush patch viability, since they provide staging posts for native birds and seedlings. Compatible plant species can also be part of a succession towards native bush and are useful as a buffer against exotic plant pests.

Figure 12: No bush connections under 10km. HJ

Criterion score 0, Table 20, (0, B1; 0, B2; 0, B3) page 178

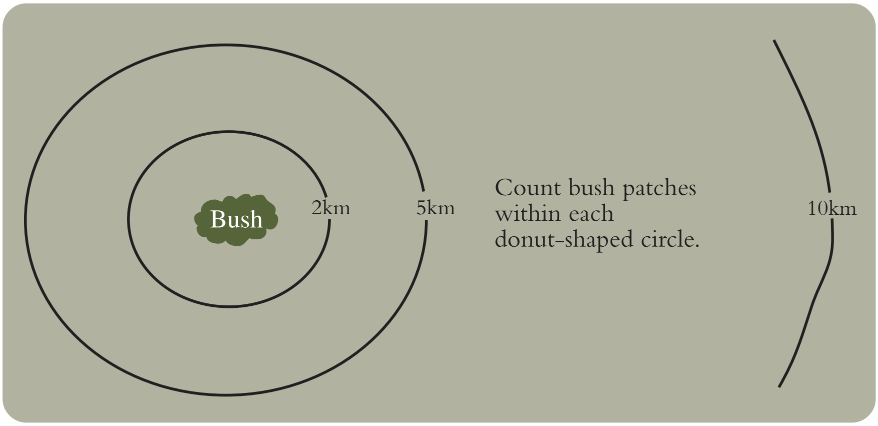
Figure 13: Oroua River corridor. HJ

Scoring

From your vantage point, or from local knowledge, identify any neighbouring bush patches. If you can't easily get onto a good vantage point in the hill country, use a topographic map or a copy of an aerial photo. Are they within calling distance or within visible distance?

You are going to be asked to assess numbers of forest patches within and outside radii (less than 2km; 2-5km; over 5km) around your site. Imagine counting bush patches within a circle and 2 larger circles around your bush patch. Differentiate size classes of under or over 25ha.

Figure 14: Distance categories for connectivity score.



Distance categories: How far away?

At 1km the crown of a 20m tawa/beech tree is about the size of your index fingernail (measured with your arm stretched out in front of your eyes).

At 2km distance, the crown of a 20m tawa or beech canopy tree is the size of your little fingernail.

At 5km distance, a 20m tree is the size of a pinhead.

Beyond 5km, individual trees are difficult to distinguish.

Figure 15: Rangiwahia (Manawatu District). Bush in foreground is within 'cooee'. Bush in background is between 2 and 5km from site. The ridgeline is beyond 5km. Ngauruhoe at a distant 90km. HJ

Criterion score 7, Table 20 (4, B1; 2, B2; 1, B3), page 178.

Count forest patches, differentiated in large (>25ha) and small (<25ha) classes, within the three given radii (within 'cooee'; less than 5km; and above 5km) to give the connectivity score for the forest patch assessed.

Connectivity of bush-wetlands

Your bush patch may contain a wetland. Natural forest–wetland transition zones are highly productive and very valuable habitats for native biodiversity. Typical indicator birds of wetland habitat intactness (fernbird, bittern and brown teal) are now rare because of habitat loss and isolation.

You may check corridor intactness upstream and downstream. Distinguish fenced native corridors and exotic riparian corridors with high to medium biodiversity values from unfenced grazing land with no biodiversity and sustainability value.

Figure 16: Wetland habitats. Rushland and podocarp swamp forest. HJ

A natural transition between two wetland habitats. McPherson Forest and Bird Reserve, Turakina.

Figure 17: Lake, bulrush wetland, and beech forest. Karioi, Mt Ruapehu. HJ

Figure 18: Wetland forest's compromised connectivity. HJ

Road disects partly fenced wetland forest, compromising inflow. Outflow grassed and unfenced. Manawatu Gorge, Tararua District.

Similarly, juvenile native fish are often prevented from accessing wetlands because of perched culverts. Check such barriers to fish migration on the right-hand side of the wetland connectivity box (see Table 20, B4; page 178).

The wetland connectivity check-box is independent of the other scoring system since few bush sites have wetlands. However, where bush patches have wetlands their management needs should be considered when developing your bush management strategy.

Figure 19: Perched culvert – a permanent barrier to native fish migration. HJ

PART 1: VISUAL BUSH SCORE

Native bush structure, resources and pests


HJ

Bush interior & margins

Stories about storeys

In this part you will assess the composition and condition of the bush interior and margins. The bush is assessed using its structure, or storeys, as a framework.

In lowland, inland areas, healthy native bush interior can consist of 5 vertical storeys. Coastal and beech forest may consist of fewer storeys, mainly the canopy and a shrub and regeneration storey. The diagram below shows a hypothetical native forest with an example of trees that are found in the lower North Island. Take some time to look at the diagram and get to know where to expect different trees.

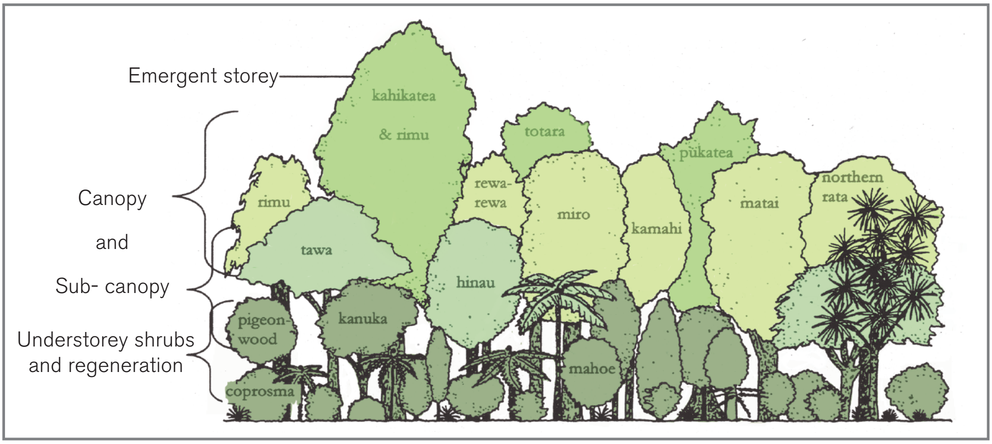
Each storey contains plant species that are an essential resource for native birds over the course of a year. The scoring system has been made easier by combining two storeys above eye-level (canopy and subcanopy) to give three vertical storeys to score:

1. Emergent storey
2. Canopy and subcanopy storey
3. Lower understorey and ground-level storey, plus the regenerating forest edge margins.

Each storey is scored using the following bush vitality categories (see Tables 21-24, pages 179-182):

- Cover proportions
- Key flowering and fruiting plants that sustain birds' life cycles
- Animal pests
- Plant pests.

Figure 20: Native bush storeys.



Key flowering and fruiting plants

Once you have scored the storey's general condition you are asked to find key fruiting or flowering plants for each of three important periods in the life cycle of native birds. Here we are scoring the continuity of resources to sustain native bird populations – how well the seasons care for the years. The three periods are:

1. **Winter and early spring**: A few native plant species provide food for native birds during these critical times**.**
   - Their accessibility determines the number of individuals of local bird populations that survive to establish breeding territories in the following spring.
   - Their extent determines the number of breeding territories that can sustain breeding pairs, which rely on both energy (nectar, fruit) and protein food sources (invertebrates) to get breeding off to a good start.
2. **Spring and summer** key plants reliably fruit or flower when fledglings require additional resources.
3. **Autumn** fruiting plants support bird migration. After the summer breeding season many birds flock together in groups to safely seek seasonal food resources and find new habitats and breeding territories. The autumn plants listed sustain native bird migrations.

Bush composition

Look at the scoring sheets (Tables 21-24, pages 179-182) and the pages with plant photos in the next chapters.

Photos of four common key plants for each of the three life-cycle periods are given for each forest storey. If you are fairly new to identifying plants, begin with finding these plants.

You only score a plant as being present if there is a viable population. This means you should be able to find at least 10 adult individuals. Do not include this plant in your scoring if you find less than 10 adult plants.

- Do, however, take note of it, as you will consider the plight of small, fragile populations when you develop your bush management strategy,

Use the flowering and fruiting tables at the back of this book (Tables 15-18, pages 173-176) if you have a plant identification book or moderate plant identification skills. They list more key plants, which you could reasonably expect to find in each forest storey or its margins to score.

- Find and score these tabled native plants for each of the three bush storeys, the forest edge and each of the three life-cycle periods to boost your understanding about the forest's vitality (see Table 21, C2-4; Table 22, D2-4; Table 23, E2-4; Table 24, F2-4; pages 179-182).

- When using your flowering and fruiting tables (Tables 15–18, pages 173–176) only add a plant to derive a period-score if it fruits or flowers for at least two months within a bird's life cycle. This is because fruiting or flowering is highly variable and increasingly uncertain at either end of the timescale for which fruiting has been recorded.

Some plants flower or fruit in different forest storeys and are repeated wherever their fruiting can sustain bird populations.

For example, kahikatea may fruit as an emergent and as a canopy tree, but not as a juvenile in the understorey. If 'many' (more than 10) kahikatea are found in both the emergent and the canopy storeys, kahikatea should receive scores in both emergent and canopy storey but not the understorey.

Animal pests

Learn to recognize signs that tell you which animal pests may be present, or most abundant. Signs include damaged fences, lack of native regeneration, browse marks on indicator plants, scratch and bite marks on bark or seeds, animal droppings and footprints.

There are three main groups of harmful mammals and animal pests

1. Browsers (deer, goats, cattle, sheep, hares) eat leaves, buds, fruit and flowers of woody plants.
2. Predators (ferrets, weasels, stoats, cats, dogs) hunt plant-eaters and omnivores.
3. Omnivores (possum; rats, mice, hedgehog, pigs) are the most versatile consumers and like humans eat anything organic; plants, animals or fungi.

Plant pests

Many environmental plant pests compete with native regeneration at the forests' edges. They include exotic climbers and, together with shade-tolerant ground cover, can degrade regenerating bush.

Some exotic plants are incompatible with native bush, because it cannot successfully compete against exotic adaptations to environmental extremes, such as tolerance to fire, prolonged cold, drought, or deep shade. Fire and shade-tolerant exotic trees are rapidly spreading across much of New Zealand's dry eastern and northern tussock and shrub lands. Unless controlled or carefully managed incompatible exotics will regenerate within native ecosystems and compete with native forests, replace native tussock and shrublands and alpine ecosystems.

Emergent storey

Tall and stately, emergent trees rise above the canopy. These are the bird-dispersed forest giants – kahikatea, rimu, miro, matai, totara; the wind-dispersed pukatea and the bird-pollinated rewarewa and rata. Perching plants make their homes in emergent trees and many are an important winter food source for birds. The logging history of the bush is often revealed by the absence of emergent trees.

Figure 21: Emergent rata trees in Westland, remind us of the former magnificence of the Ruahine Range's northern rata forest. J.Janssen

Emergent cover scores

A healthy native bush will have no less than 20% emergent trees visible above the canopy. From a good vantage point, look over the whole of the canopy. Estimate the number of emergent trees using Figures 22-24, pages 38-39 as a guide.

Figure 22: Emergent podocarp storey at Turakina. HJ

Podocarp storey emerges over canopy trees in the foreground (criterion score 10, Table 21, C1; page 179).

Figure 23: Emergent rata storey at Bushy Park, Wanganui District. HJ

Scattered emergent rata and kahikatea over a canopy of tawa and regenerating pukatea (criterion score 8, Table 21, C1; page 179).

Figure 24: Emerging rewarewa, Vinegar Hill, Rangitikei River. HJ

A few emerging trees over tawa and pukatea canopy (criterion score 2 Table 21, C1; page 179).

Figure 25: The value of original native trees. HJ

Another giant female rimu of a small local population down. Did the timber price reflect the true value of an 800-year-old matriach? Compare Figure 146, page 105.

If this bush has no emergent storey, start assessing the canopy storey.

Now that you have assessed the spatial aspects of the bush patch and the emergent storey, walk into the bush and make observations for each of the following scoring sections. Note in the 'comments' column of Table 21, C2-4 (page 179) how many of the trees listed in this section you can find. Start with the most common trees and use the photos in the list to help identify them.

Figure 26: Coastal bush without an emergent storey. HJ

Key plants for native birds

Emergent trees are the most prolific source of food and shelter for many of our native birds. The female podocarps' fleshy seeds ripen at different times of the year; together they can provide food over an entire year.

- Female miro produce ripe seed from early autumn to late winter
- Female matai seed from spring to late summer
- Mountain totara seeds over summer
- Lowland totara, kahikatea and rimu seed from summer to early winter.

All forest giants and tall canopy trees support winter-fruiting perching lilies and climbers such as rata vines, shining broadleaf and supplejack, providing ideal habitats for most native bird species. Such associated plant species also synchronise flowering and fruiting so that their pollen and seeds are carried forth, contributing to birds' food resource continuity over the year.

The female podocarp trees – rimu, kahikatea, miro, matai, and totara – are variable in their seed production. Mast seeding years[5] often follow dry summers and recur only every 3-5 years. Seed abundance is usually followed by lean years. During this part of the cycle a fruiting understorey often comes to the rescue of besieged bird populations. Food is generally abundant over summer, unless severe droughts or prolonged wet weather affect fruit set and invertebrate abundance.

Scoring

Each of the following three pages corresponds to one of three important life-cycle periods for native forest birds. Each page shows four of the more common plants that can sustain native bird populations during that period.

With your plant identification book use Table 15 (page 173) in the Appendix and find a more complete list of key plants that you can reasonably expect to find. Use Tables 16-18 (pages 174-176) for the other forest storeys.

When you have found a listed plant, check the times when it fruits or flowers and add it as one species to the appropriate life-cycle period on your score sheet (Table 21, C2-4; page 179). Note that you only add a plant to your scoring if it fruits or flowers for at least two months of any of the three life-cycle periods.

5 Mast seeding years refer to periodic overabundance of fruiting. The original meaning refers to fruit of forest trees eaten by livestock (pigs and cattle).

Winter and early spring food sources for bird survival

Figure 27: Miro♀
(Prumnopitys ferruginea).

Miro grows to 25m and can be found growing in low-altitude, hill slope forests throughout New Zealand. The bark has a dotted, scaly surface. The inside of the scale is brown. Large red fleshy seeds ripen over winter, from April to October. Unlike the matai, the juveniles' leaves are similar to the adult tree. Native pigeons fly great distances to eat the ripe fleshy seeds on female trees.

Figure 28: Climbers: red rata vine, aka kura,
(*Metrosideros fulgens; M. carminea).* A Dijkgraaf DOC

New Zealand has several flowering rata vines that can climb quite large trees. Found in lowland forests throughout the North Island, this orange-red flowering vine is in bloom from autumn through to spring. It is an important food source for honeyeaters – tui, bellbirds and stitchbirds. It is also popular with kaka.

Figure 29: Epiphytes[6], kowharawhara
(Astelia solandri). HJ

Kowharawhara can provide a year-round food supply for smaller birds. *Astelia* are distinguishable by their green leaf base and drooping leaves.

Figure 30: Kahakaha
(Collospermum hastatum).

Kahakaha has a dark leaf base and upright leaves. It fruits over the lean winter months.

6 Epiphytes grow self-sufficiently on the branches of host plants.

Spring and summer food sources for breeding birds

Figure 31: Northern rata (*Metrosideros robusta*). S Barnett, DOC

The life-story of this majestic tree is quite extraordinary. A small wind-carried seed lands on epiphytes, growing in a tall tree's crown. The seed germinates and sends aerial roots to the ground that supply the young rata with nutrients to sustain growth. Over time, the epiphytic rata replaces the aging host tree. Its strong interconnected roots provide lasting stability to steep hill slopes and diverse habitats that sustain entire native communities.

Figure 32: Rewarewa (*Knightia excelsa*). HJ

Rewarewa is a common emergent tree (up to 30 m) in regenerating native forest. The bark is smooth. Alternate leaves are thick with pointed teeth. Like rata, rewarewa flowers are an important energy source for nesting bellbird and tui.

Figure 33: Kahikatea (*Dacrycarpus dacrydioides*). HJ

The kahikatea is New Zealand's tallest native tree, growing to more than 60m with a lineage reaching back 180 million years. It is found throughout New Zealand in forests up to 600m above sea level. Kahikatea grows in swamp forests.

Figure 34: Mistletoes (*Peraxilla spp, Alepis flavida* and *Ileostylus micranthus*).

Peraxilla spp and Alepis flavida grow on mountain and silver beech. Flowers of *Peraxilla* are bright red, the berries are yellow to orange and both *Alepis'* flowers and berries are later and yellow-orange. Ileostylus *micranthus* grow on coprosmas, lacebarks, manuka, totara. Flowers are greenish-yellow and berries are bright yellow.

Autumn food resources for bird migration

Figure 35: Matai
(*Prumnopitys taxifolia*). HJ

Matai grow on river terrace and volcanic soil in lowland forest. Its most distinctive feature is its 'hammer-marked' bark scales that are pale on the inside, as opposed to reddish for miro. Mature matai foliage is blue-green and the straight leaves have whitish undersides. Matai seeds are like small dark plums.

Figure 36: Rimu ♀
(*Dacrydium cupressinum*). D Merton DOC

The tree grows throughout New Zealand, and before the arrival of humans it often lived for 1000 years or more, and was the dominant tree in many forests. The rimu is beautiful at all stages of its life cycle. When young, the cascading, weeping, light-green foliage marks the rimu as being one of the world's most attractive conifers. It can reach heights of 60 metres.

Figure 37: Totara ♀
(*Podocarpus totara*). B Smith DOC

Totara trees rarely grow more than 30m in height, and prefer dry but fertile, well-drained soils. This tree lives up to 1000 years. The massive trunk of the mature totara is tall and straight with thick, deeply furrowed bark. The dense and attractive foliage if compared to other podocarps is rather prickly to the touch. Totara trees grow throughout New Zealand. Not surprisingly stock avoid totara, which presents opportunities for native afforestation in areas that are difficult to fence.

Figure 38: Shining broadleaf puka
(*Griselinia lucida*). HJ

This epiphyte has shining broad leaves and longitudinally grooved roots that often dangle towards the ground next to the host tree.

Animal pests – possums

Few predators frequent the emergent storey and earthbound browsers haven't affected the plants in this storey since the time of the dinosaurs. But recently arrived climbing omnivores – particularly possums – are persistent threats to life in this storey. Possums are common everywhere except in areas where they are systematically controlled. Possums eating leaves, shoots, flowers and fruits are the main threat to the canopy condition.

The possum browse assessment (see Table 1, page 46) is to identify the species that are most under siege and the severity of possum damage to the site. The condition of northern rata, scarlet rata vine and totara in the canopy and emergent storeys indicates the degree to which possums lay siege on native bush.

Possum browse monitoring shows the severity of the local possum infestation and which trees they threaten most. However, possums do not use all available food uniformly, so one rata tree can be completely defoliated, while another nearby is left untouched until later.

Alternative assessments include night shoots and traps set along transect lines.

Figure 39: Lethal possum damage. HJ

Figure 40: Effective possum eradication.

Horizons Regional Council

Table 1: Scale to assess proportion of foliar browse damage on leaf cover

FOLIAGE COVER

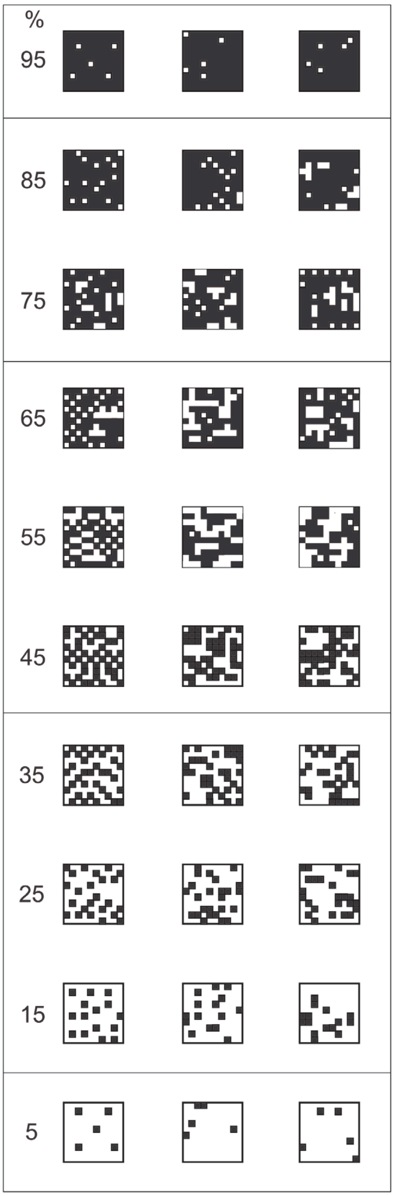


TABLE DESIGN, DR IAN PAYTON, LANDCARE RESEARCH

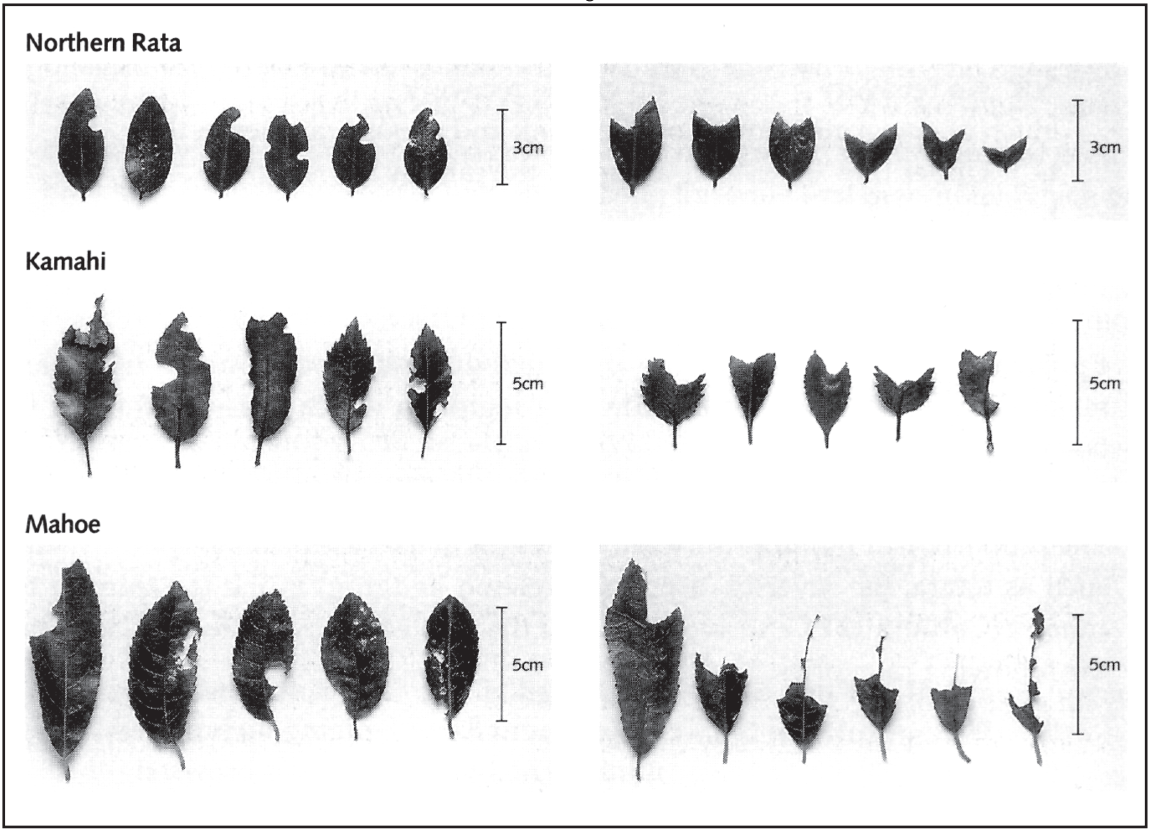
Foliar browse assessment method

Assess possum damage in the canopy as a percentage area of a circle made with your hands outstretched over your head and your index fingers and thumbs touching each other. This circle represents 100% of the area. Look up and estimate the percentage of leaf versus sky. Place the circle where you would expect leaves to be. Don't place the circle over big gaps, trunk and branches or parts of trees with climbers in the canopy. Subtract the defoliated percentage and repeat a few times to assess possum browse severity on a particular canopy tree. Repeat for other indicator tree species to assess damage to site. Compare with Table 1 to help you find approximate proportions.

- As a general rule, a tree with 75% leaf cover is healthy, while 55% (or less) is severely possum-damaged and stressed.
- Totara that have passed the juvenile growth stage are naturally dense trees. 'Healthy' for a mature totara is 95% foliage cover – damaged totara have 75% or less.

Possum browse can be readily distinguished from damage done by caterpillars or stick insects. Insects produce holes and straight or wavy patterns, while possums tear leaves and produce jagged leaf stumps.

Figure 41: Leaves showing difference between possum-browsed leaves (right) and insect-damaged leaves (left).



Canopy and subcanopy storeys

The canopy is the 'forest roof'. Canopy trees can make use of all available light energy. Together with the emergent trees, they are most exposed to the elements, having to cope with stresses of drought, heat and strong winds. They protect the lower storeys and help suppress most shade-intolerant plant pests. Forest canopy heights can range widely, from the 5m high coastal kohekohe, ngaio forest, or regenerating treefern and manuka shrub to the 30m mature tawa and beech canopy.

The common canopy trees will vary depending on where you are. Kohekohe form a canopy tree in a few coastal forest remnants. Tawa are most common throughout the lower North Island below 400m. Black beech can be found on ridge spurs and on less fertile soils. Other important lowland canopy trees include titoki, pigeonwood and hinau. Fivefinger, lancewood and mahoe may be found as canopy trees on steep slopes or in regenerating bush. Kamahi replace tawa in the foothills of the Tararua ranges, above 400m and are replaced by beech forest above 600-700m in the axial ranges.

Subcanopy trees are more shade tolerant. Many native birds nest and find food to feed their offspring amongst mahoe and pigeonwood. Other subcanopy trees are juvenile canopy and emergent trees. An open subcanopy normally means that the understorey was grazed out some time in the last 10 to 40 years. Possums browse the subcanopy trees' crowns, and scratches in their thin, young bark often serve animal pests as territory markers.

Canopy and subcanopy cover scores

Take some time to look over the whole of the canopy. Can you see any gaps where there are no trees in the canopy?

Using the photos as a guide, estimate the proportion of gaps. A highly stressed canopy can have about 30% gaps.

Assess the integrity of the subcanopy storey. Try to distinguish between regenerating canopy and emergent species from true subcanopy species to get an idea about this bush's history. Absence of palatable species indicates a history of stock access or abundant animal pests.

Figure 42: Coast to crest canopy – a mosaic of habitats. HJ

Figure 43: Beech forest canopy gap. HJ

Canopy cover scores

Figure 44: The continuous canopy of Bushy Park, Wanganui District. HJ

An undisturbed and well-managed lowland forest has few canopy gaps (criterion score 4, Table 22, D1; page 180).

Figure 45: Moderate canopy cover. HJ

Tree ferns and shrubs appear in a gap of canopy trees on the left hand side (criterion score 2, Table 22, D1; page 180).

Figure 46: A degraded forest canopy. HJ

Large canopy gaps of a browsed forest (criterion score 1, Table 22, D1; page 180).

Subcanopy cover scores

Figure 47: Good cover of subcanopy and regenerating plants. HJ

This healthy subcanopy consists of many plant species (criterion score 4, Table 22, D1; page 180).

Figure 48: Moderate subcanopy cover typical for beech forest. HJ

Scattered mamaku under hard beech. Podocarp broadleaf forests, usually contain higher subcanopy plant species diversity (criterion score 3 for beech forest, criterion score 2 for podocarp broadleaf forest, Table 22, D1; page 180).

Figure 49: Poor subcanopy cover.

No regeneration, due to persistent browsing pressure (criterion score 1, Table 22, D1; page 180).

Key plants for native birds

Identify as many plant species as you can find for each seasonal category (see pages 53-55 (Figures 50-61) and write down the appropriate score (Table 22, D2-4; page 180). If you find black sooty mould on the bark of beech trees, look for the slender wax tubes with honeydew of the beech scale insect. Score this invertebrate **keystone species** on your native animal score sheet (Table 25, page 183).

With your plant identification book, use Table 16 (page 174 in the Appendix) for a more complete list of key plants that you can reasonably expect to find.

When you have found a listed plant, check the times when it fruits or flowers and add it as one species to the appropriate life-cycle period on your score sheet. Remember, only add a plant to your scoring if it fruits or flowers for at least two months of any of the three life-cycle periods.

Winter and early spring food sources for bird survival

Figure 50: Pigeonwood
(*Hedycarya arborea).* HJ

A lowland and lower mountain forest tree with bright orange berries. The leaves have small pointed teeth and the leaf's lower midrib is reddish.

Figure 51: Kohekohe
(*Dysoxylum spectabile*). HJ

S Barnett, DOC

A coastal canopy tree (15 m) of subtropical origin. Its flowers and seed-capsules, containing 3 large seeds, are on the tree-trunk.

Figure 52: Swamp maire
(*Syzygium maire*). HJ

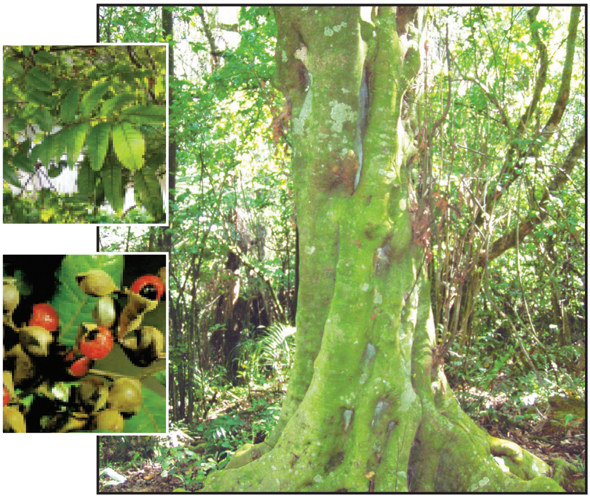
This 10m tree is found in swamp and bog forests. The white flowers are manuka-like, the berries red, its bark is smooth and pale (like its autumn-fruiting relative, the rohutu, which prefers drier river terraces in coastal and lowland forests.)

Figure 53: Broadleaf
(*Griselinia littoralis).* HJ

Broadleaf is found in lowland to subalpine forest and shrubland. The bark is rough and the large fleshy leaves yellow-green.

Spring and summer food sources for breeding birds

Figure 54: Titoki
(*Alectryon excelsus*). HJ



Common in coastal and lowland forest throughout the North Island and upper South Island. A beautiful small tree with smooth dark bark. 4-6 leaflets are attached alternately to the leaf stalk. Furry seed capsules contain black seeds, which are enclosed by red fleshy arils.

Figure 55: Black maire ♂
(*Nestegis cunninghamii).* HJ

Once widespread in the southern North Island, a few of these highly regarded trees survive today in remote forest remnants. Rough, corky bark. Ripe fruit are red or yellow, and generally appear from early spring and may be found until late autumn.

Figure 56: Tawa
(*Beilschmiedia tawa*). HJ

Very widespread canopy tree in lower North Island lowland forests. Fruit ripens from late spring to summer. Large-seeded tawa, hinau, pigeonwood, matai, miro and karaka rely entirely on kereru for their seed dispersal.

Figure 57: White rata vines (*Metrosideros diffusa* and *Metrosideros perforata).*

White flowers are attached to woody twigs on this slender liane. Not shown is the *Metrosideros colensoi* with overlapping leaves and flowers in terminal clusters.

Autumn food sources for bird migration

Figure 58: Hinau (*Elaeocarpus dentatus*). HJ

P Anderson, DOC

Hinau grows to 20m, a canopy tree of both islands' lowland forests. The bark is rough with narrow longitudinal fissures (vines on left *Griselinia lucida*; vines on right *Metrosideros perforata*). The leaves are widest near the tip. Flowers are white, petals are deeply incised. The large berry is purplish black.

Figure 59: Kaikomako (*Pennantia corymbosa*). HJ

Fruiting female trees are an irresistible favourite of bellbirds. This 10m tall lowland forest tree is found throughout New Zealand. Twiggy juvenile kaikomako (see leaves bottom of picture) can often be seen together with adult leaves (see middle leaf) on a young tree.

Figure 60: Fivefinger, Puahou (*Pseudopanax arboreum*). HJ

Fivefinger is easily recognised by leaves consisting of 5-7 leaflets, each with large teeth along its margins. A common tree of up to 8m, found in lowland forests and regenerating forest as far south as coastal Otago. It is an indicator plant for possum and deer browse.

Figure 61: Nikau palm (*Rhopalostylis sapida*). HJ

Nikau can be common in coastal and warmer inland forests. Ripe red berries from the previous season often sit below this season's inflorescence of small pink flowers.

Animal pests

Predators such as cats and stoats can reach and kill many nesting birds and their offspring in both storeys. Omnivores of this storey are possum and rats. Possums are a major threat not only to native insects and nesting birds but also to over 70 native trees, epiphytes and climbers. Possums selectively remove certain favourite species over many decades.

The Ruahine Ranges provide a sad example of catastrophic rata-kamahi canopy-dieback as a result of an unchecked and thriving possum population about 25 years after possums first colonised the area.

The objective of a possum browse assessment is to identify the species that are most under siege and the severity of possum damage to the site.

Use the foliar browse assessment method described in the previous chapter. For trees with very small leaves, such as totara, you need to estimate the amount of hedging. Figures 41 and 64 show you how to distinguish possum bite marks from insect bites. Try to estimate how much fresh dieback (recently defoliated live twigs) there is in the upper third of the tree.

Figure 62: Possum browsing fivefinger flower buds. R Morris DOC

Figure 63: Dieback caused by possum, Susceptible mistletoe (inset).

Figure 64: Possum-browsed leaves.

Look for browse marks on these common canopy and subcanopy plants. These species easily die as a result of persistent browsing of leaves and buds. Meanwhile an adjacent tree can remain untouched, until the demise of the preferred food source and the possum switches to this tree.

Table 2: Indicator plants for possum pressure on native bush

Animal pest indicator plants		*Predominant threats*
Black and silver treeferns	*Cyathea spp*	Possum
Hinau	*Elaeocarpus dentatus*	Possum
Kaikawaka	*Libocedrus bidwillii*	Possum
Milk tree	*Paratrophis banksii*	Possum
Mistletoe species	*Alepis spp*; *Peraxilla spp*	Possum
Pohutukawa	*Metrosideros excelsa*	Possum
Rata	*Metrosideros robusta*	Possum
Scarlet rata vine	*Metrosideros fulgens*	Possum
Tawa	*Beilschmiedia tawa*	Possum
Titoki	*Alectryon excelsus*	Possum
Totara	*Podocarpus totara*	Possum
Mahoe (whiteywood)	*Melicytus spp*	Possum, deer, goats
Kotukutuku (tree fuchsia)	*Fuchsia excorticata*	Possum, deer, goats
Fivefinger	*Pseudopanax arboreus*	Possum, deer, goats, stock
Kamahi	*Weinmannia racemosa*	Possum, deer, goats, stock

Plant pests

A few exotic and one native climber (*Muehlenbeckia australis*) may create a risk to canopy species. Plant pest climbers usually establish at the forest edge or in canopy gaps. Old man's beard and banana passionfruit can overgrow canopy trees from these sites. Some canopy trees may succumb to their vigorous growth, which potentially leads to further canopy collapse.

Native canopy and regenerating trees can rapidly close the gap, where the vines are cut at ground level and painted with herbicide. A closed canopy removes climbing plant pests' regenerative advantage.

Figure 65: Banana passionfruit vine (*Passiflora mollissima; P. caerulea*). HJ

Understorey shrubs and regeneration

The understorey is made up of a variety of shade-tolerant shrubs, ferns and juvenile plants. Juvenile plants often dramatically change appearance as they adapt to the different conditions in the upper forest storeys. Their adaptation to survive decades under the shade of the top storeys is remarkable, as is their ability to respond to more light and rapidly grow to fill any canopy gaps.

Any plant growth at low light levels is very precious and many native shrubs and trees have evolved divaricating growth forms to guard against loss from plucking bird beaks. The rapid extinction of browsing birds, like the moa, is commonly linked to its low rate of reproduction, which is an adaptation to understorey plants' conservative nutrient budget and slow growth.

However, stock and browsing pests can kill off successive generations, progressively depleting the forest's seed banks and eliminating one species after another. Any native bush patch has no future if its understorey is consistently browsed, since the browsers' high-energy requirements exceed by far the regeneration capacity of most nutrient conserving understorey plants.

SHELTERING STOCK

Cattle, pigs and deer originate from European forest parklands and do well where shelter and some browsing are available. Many farmers have already planted tree lucerne, poplars, oaks and elms for this purpose.

Some farmers have in the past used native bush remnants as stock shelter or as a supplementary food source in dry summers. This practice is not sustainable and stock needs to be excluded from the few remaining native bush patches. As you develop your bush management strategy you may consider planting additional trees that provide stock with shelter and that have adapted to occasional browsing or seed consumption by mammals. Examples on the uses of compatible exotic trees on the farm are in Part 2, Resilient Landscapes and Tables 12 (page 135-138) and 14 (page 143-146).

Understorey and regeneration cover scores

Assess the integrity of the understorey. How far into the bush can you see?

Compare regeneration cover using the following figures to derive your score. Look for browse damage (ripped leaves and shoots).

Distinguish between regenerating species from the upper storeys from true understorey species (coprosmas and kawakawa) to get an idea about this bush's history. Absence of palatable species indicates a history of stock access or abundant animal pests.

Figure 66: Good understorey cover. HJ

Criterion score 6, Table 23, E1; page 181.

Figure 67: No understorey, browsed and no regeneration. Horizons Regional Council

Criterion score 1, Table 23, E1; page 181.

Key plants for native birds

Again, using the photos and the fruiting and flowering tables, identify any key plant, check the times when it fruits or flowers and add it as one species to the appropriate life-cycle period on your score sheet. Note that you only add a plant to your scoring if it fruits or flowers for at least two months of any of the three life-cycle periods.

Native animal species with key ecosystem functions

Aside from keystone plants, you are also most likely to positively identify keystone animals in the understorey, Compare Chapter 4: Native Animals and score their presence on Table 25 (page 183). Where you get a high plant score you are more likely to find bird and invertebrate species that also play a key role in sustaining native ecosystem processes. Note that you are more likely to find invertebrates in the warm seasons.

Winter and early spring food sources for bird survival

Figure 68: Pate
(*Schefflera digitata*). HJ

Shrub of moist lowland forests. Distinguished from fivefinger (*Pseudopanax arboreum*) by finely serrated leaf margins.

Figure 69: Kawakawa
(*Macropiper excelsum*). HJ

Branches zigzag and leaves are heart-shaped. Flowers and orange fruits on spikes appear throughout the year.

Figure 70: Kotukutuku
(*Fuchsia excorticata*). J Janssen

Fuchsia is easily recognised by its orange papery bark and bluish-red flowers from late winter. Sheds leaves over winter. Often found near streams and bush margins. Tree fuchsias attract a wide range of native birds. From early spring fuchsia provides nectar-feeding birds with valuable energy. From early to late autumn birds are attracted by fuchsia fruit. Fuchsia is an indicator plant for possum presence.

Figure 71: Taurepo, NZ Gloxinia,
(*Rhabdothamnus solandri*). P Anderson DOC

Understorey shrub with beautiful and unusual flowers.

Spring and summer food sources for breeding birds

Figure 72: Mapou
(*Myrsine australis).* HJ

Easily identified by its wavy-edged leaves and reddish stems. Berries ripen from October to February. Important reliable spring and summer food source.

Figure 73: Turutu, NZ blueberry,
(Dianella nigra). J Janssen

Turutu forms tussocks of around 50 cm height and grows on the forest floor and riverbanks throughout the main islands. Its greenish-white flowers appear from late spring and its vivid blue berries ripen through summer and autumn.

Figure 74: Mountain or narrow-leaved mahoe
(*Melicytus lanceolatus*).

From mid-altitudinal hill country and mountain forests. Female tree flowers from early winter. Berries ripen from mid-winter to late-summer.

Figure 75: Mingimingi
(*Cyathodes fasciculata*). HJ

Grows in open shrub and forest on rocky substrate. This mingimingi has been browsed by goats. The name refers to 3 small shrubs with small red or bluish berries. Soft-leaved *Cyathodes fasciculata* has red berries from early spring to late autumn. Prickly mingimingi, *Cyathodes juniperina* has reddish berries throughout the year. *Coprosma propinqua* ripens bluish fruit in autumn.

Autumn food sources for bird migration

Figure 76: Mahoe/whiteywood (*Melicytus ramiflorus).*

One of the most common understorey or scrub canopy trees in lowland forests throughout NZ. Scented flowers and bluish fruit provide a reliable food resource from late summer to autumn.

Figure 77: Large-leaved coprosma (*Coprosma grandifolia).* HJ

45 Coprosma species are endemic to New Zealand. They are easily recognised by the fused bases of paired, opposing leaves. Leaves have pits on either side of mid-vein on leaf undersides. The stipule (protection for the next set of leaf buds) is also a distinctive feature of the family. The fruit ripens late in the year and sometimes persists until the next crop. Important reliable food source.

Figure 78: Kareao, supplejack, (*Ripogonum scandens).* HJ

This plant is found in lowland native forest throughout NZ. The supplejack flowers are small, but the red berries appear in large clusters and are especially loved by native pigeons and kokako. Maori call this plant kareao and the tough, pliant vines were especially useful in making fishing pots and many other articles.

Figure 79: Poroporo (*Solanum aviculare).* Rata Janssen

Shrub to 3m high in understorey and forest edge. Flowers from September. Berries ripen from November and persist until winter.

Animal pests of the understorey

Predators of the understorey include mustelids (weasels; stoats; ferrets), cats, and dogs. Omnivores include possums, pigs, hedgehogs, and rodents (rats and mice). Look out for animal pest signs and native indicator birds and invertebrates.

The absence of native indicator animals shows pressures from introduced predators, omnivores and habitat loss. Score native animal presence on Table 25 (page 183) using the 'Native Animals' chapter for identification (pages 85-93).

Score 1 for each animal pest category (predators, omnivores, browsers) that is not present, or is effectively controlled (Table 23, E6; page 181). Contact the Department of Conservation or your Regional Council to set up tracking tunnels, possum trap catch monitoring, and initial pest control.

Browsers and omnivores

Browsing animals eat the understorey of the forest, killing young trees and forever depleting the forest's natural diversity as old trees die and only the few unpalatable species are left to regenerate. The main understorey browsers are goats, deer, cattle, sheep and horses and the omnivorous possum. As well as eating leaves, some browsers, like goats, deer, horses and cattle ring-bark regenerating trees.

Look out for animal signs, including:

- deer campsites, flattened grass in sheltered, isolated places
- animal footprints in muddy places
- animal droppings
- bite marks on leaves and bark of indicator understorey plants.

Fuchsia and fivefinger are understorey plants where possum browse can be distinguished by ripped browse marks in leaves. Tree fuchsia shed all or most of their leaves every winter; hence, damage always indicates recent browsing – indicating immediate pest pressure.

Figure 80: Fallow deer (*Dama dama*) damage in beech forest.

Figure 81: Bark damage (ungulates). HJ

Chew marks and territory markers on bark.

Figure 82: Bark scratch marks (possum). HJ

Figure 83: Red deer (*Cervus elaphus*) hoof prints.

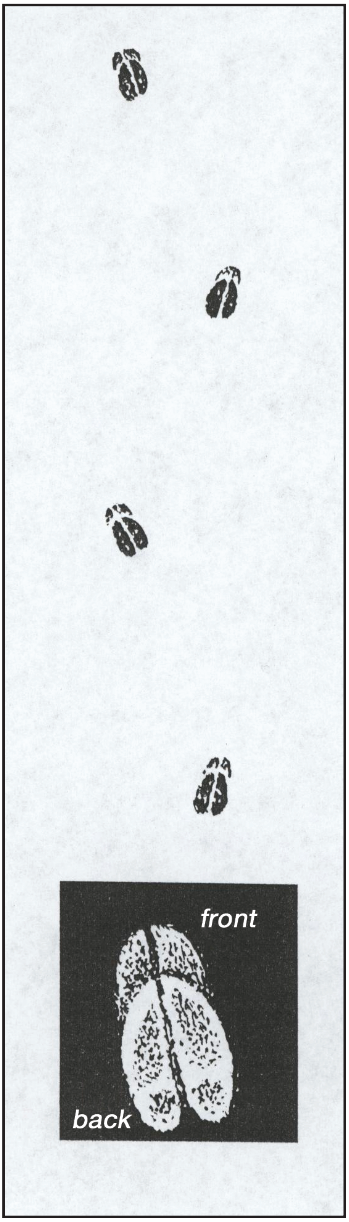


Figure 84: Wild pig (*Sus scrofa*) hoof prints, pig tracks and boar rub-marks on tree ferns (HJ and Dan Steele)

Figure 85: Goat droppings. HJ

Figure 86: Possum droppings. HJ

Look for browse marks on these common understorey indicator plants –

Figure 87: Assorted browsers' delights and indicator plants (mahoe, fivefinger, hangehange, coprosma).

Figure 88: Hangehange, NZ privet (*Geniostoma ruepstre*). HJ

Figure 89: Kanono (*Coprosma grandifolia*) browsed by goat, deer or stock. HJ

Figure 90: Hen and chicken fern (*Asplenium bulbiferum*). HJ

Table 3: Native indicator plants for animal pest presence	
Animal pest indicator plants	*Predominant threats*
Hen and chicken fern *(Asplenium bulbiferum)*	Deer, goats
Stinkwood *(Coprosma foetidissima)*	Deer, goats
Kanono (*Coprosma grandifolia)*	Deer, goats
Hangehange (*Geniostoma rupestre)*	Deer, goats
Lacebark (*Hoheria populnea)*	Deer, goats
Ribbonwood (*Plagianthus betulinus)*	Deer, goats
Mingimingi (*Leucopogon spp, Coprosma spp)*	Goats
Tree fuchsia (*Fuchsia excorticata)*	Possum, deer, goats
Mahoe, whiteywood (*Melicytus spp)*	Possum, deer, goats
Fivefinger (*Pseudopanax arboreus; P. colensoi)*	Possum, deer, goats

Plant pests

Look out for shade-tolerant and competitive plant pests of the understorey. Identification guides and advice on plant pest eradication are available from DoC and your Council. If you do find plant pests, assess their extent (Table 23, E7 (page 181) and Table 26 (page 184)). Consider eradication options when you diagnose your bush patch (Figure 145 page 99) and analyse your options for a bush management strategy.

Table 4: Shade tolerant and invasive plant pests	
Australian white monkey apple (*Acmena smithii*)	Competes with native regeneration.
Climbing asparagus (*Asparagus scandens)*	Prevents regeneration of some native plants.
White bryony (*Bryonia cretica; sbsp dioica)*	Competes with native regeneration.
Wild ginger, Kahili ginger (*Hedychium spp)*	Prevents regeneration of most native plants.
Holly (*Ilex spp)*	Competes with native regeneration.
Chinese tree privet (*Ligustrum lucidum; L. sinense)*	Competes with native regeneration.
Evergreen buckthorn (*Rhamnus alaternus)*	Competes with native regeneration.
Ivy (*Senecio mikanioides; Hedera helix)*	Prevents regeneration of some native plants.
Woolly nightshade (*Solanum mauritianum)*	Competes with native regeneration.
Jerusalem cherry (*Solanum pseudo-capsicum; S. diflorum)*	Poisonous, bird-dispersed. Competes with native regeneration. Its abundance indicates browsing pressure.
Tradescantia (*Tradescantia fluminensis)*	Ground cover. Prevents regeneration of most native plants.

Table 5: Shade tolerant and invasive exotic trees	
Firs (*Abies spp)*	Compete with native ecosystems
Douglas fir (*Pseudotsuga menziesii)*	Adapted to fire regeneration. Displaces native forest and tussock ecosystems
Cedars (*Thuja spp)*	Adapted to fire regeneration. Displaces native ecosystems
Hemlocks (*Tsuga spp)*	Adapted to fire regeneration. Displaces native ecosystems

Figure 91: *Tradescantia fluminensis*. HJ

Tradescantia spreads by vegetative means from fragments of plant material. It is a typical 80/20 plant in terms of pest control efficiency. It is easy to control large areas with a rake but near impossible to eradicate. Always be careful to clean your tools and shoes to prevent its spread.

Figure 92: Wild ginger (*Hedychium spp*).

This shade-tolerant plant prevents native regeneration and is difficult to control. Tubers need to be dug up and destroyed.

Bush margin, shrub and regenerating bush

You have completed assessing the bush patch interior. You now need to walk around the bush perimeter and assess the bush margin. Broken fences and establishing plant pests indicate future problems in the making.

The bush margin is often the transition zone between native bush and introduced species. Natural transition zones (ecotones) are highly productive and biodiverse (see pages 111-112). Sustainably managed, such transition zones can become a farm asset rather than a liability. Here, introduced plants can have a place in sustaining your bush patch. For example, compatible tree crops (see Part 2: Resilient Landscapes from page 119) can be planted to precede and shelter regenerating shade-tolerant native understorey. In managed margins, compatible adaptations, different tolerances and responses to local environmental conditions and plant competition are used to produce superior harvestable specimen trees (see Reafforestation models, pages 126-138). Plant and animal pests are manageable at low levels following an initial pest control operation. Ask your Council or DoC for advice and support.

Figure 93: Natural wetland bush margin. A year's food supply growing in one place. From left kowhai, cabbage tree, coprosma, lancewood. HJ

Edge composition scores

Assess the proportion of native plants occupying the forest edge. Distinguish between compatible exotic species (see explanation below and compare Table 14, pages 143–146) and incompatible exotic plants and plant pests (compare Table 7, page 83). Score edge composition (see Table 24, F1, page 182).

Figure 94: Native edge forests in healthy condition. HJ

Criterion score 6, Table 24, F1; page 182

Figure 95: Regenerating putaputaweta, (marble leaf) (*Carpodetus serratus*) forest edge. HJ

Criterion score 6, Table 24, F1; page 182

Figure 96: An grand chestnut tree in flower. HJ

Figure 97: Majestic linden and elm trees. HJ

Criterion scores of 4-5, where compatible exotic trees shelter native bush (Table 24, F1; page 182).

Compatible exotic plants

Any good number of compatible exotic plants near the native bush edge or as a linking corridor scores 4 to 5 under 'Edge and regenerating shrub' (Table 24, F1; page 182).

Many exotic plants are not pests but can assist the native bush patch. They are unlikely to be found within the bush, but on the margin or nearby, effectively enlarging a native bush patch. Wherever they are planted for forestry purposes they provide excellent opportunities for natural native regeneration. They occupy a space in time and are naturally succeeded by much more shade-tolerant native species. Planting compatible exotic forests or corridors may not only be appealing to the farmer and farm forester, it is also preferable for biodiversity restoration purposes, wherever good native plants cannot reliably be sourced locally. In such cases, leave native plant propagation to native birds.

Compatible exotic trees (Table 14; pages 143-146) have co-evolved with mammals and many have been used for centuries to supplement stock diet (pigs and cattle have been fattened on oak, beech, walnut and hickory mast, windfall apples, and plums.) These trees can also serve as decoys to attract game and control possums and other animal pests. Domestic stock, deer and other ungulates prefer elm and tree-lucerne (tagasaste) leaves to those of many natives.

Key plants for native birds

With your plant identification book identify as many plant species as you can find for each seasonal category (see pages 75-77, Figures 98-109). Use Table 18, page 176 for more complete list of key plants. Remember, only add a plant to your scoring if it fruits or flowers for at least two months of any of the three life-cycle periods.

In regenerating bush, scrub of the forest edge, identify as many species as you can find for each seasonal category using Table 24, F2-F4, page 182, and write down the appropriate score.

Native animal species with key ecosystem functions

You are likely to encounter native animals while you assess forest edge plants. Be prepared to score their presence on Table 25, page 183. View native animals for identification in Chapter 4: Native Animals, pages 85-92.

Winter and early spring food sources for bird survival

Figure 98: Small-leaved kowhai (*Sophora microphylla).* HJ

J.Janssen

Beautifully shaped kowhai in prime coastal forest habitat. Flowers that provided nectar to tui and bellbirds from late winter to early spring now cover the forest floor at the end of the flowering season. Kereru feed on leaves and flowers. It is the most widely distributed of all kowhai species.

Figure 99: Bellbird feeding on honeydew from the beech scale insect (*Ultracoelostoma assimile*) on hard beech. HJ

Honeydew is an important year-round energy source for many native birds. The scale insect can be found on black, mountain, hard, and red beech (*Nothofagus solandri; N. sol. var sol.; N. truncata; N. fusca*), particularly at exposed and warm sites.

Figure 100: Fivefinger (*Pseudopanax arboreus)* left and lancewood (*Pseudopanax crassifolium*) right. HJ

J Janssen

These pioneer trees are often found in regenerating bush and readily adapt to most sites.

Figure 101: Putaputaweta. (*Carpodetus serratus)* HJ

Tree of forest margins and riparian zones.

Spring and summer food sources for breeding birds

Figure 102: Ti Kouka, cabbage tree (*Cordyline australis*). HJ

J Janssen

Pioneering tree with remarkable adaptability and resilience to withstand forest clearance and fire. Nowadays killed by a bacterium. It readily establishes on most soil types.

Figure 103: Kanuka (*Kunzea ericoides*). HJ

Kanuka and manuka nectar is sought after by bellbird and tui. Kanuka trees are taller (15m) than manuka (4m). Kanuka flowers are smaller (0.5cm) than manuka (1cm). Kanuka leaves are softer than prickly manuka leaves.

Figure 104: NZ flax (*Phormium tenax*). J.Janssen

This plant grows in swamps and on almost any other substrate. Flowers in early summer. Rich source of nectar for tui and bellbirds.

Figure 105: Taihape kowhai (*Sophora godleyi*). HJ

This species grows in the central North Island. It flowers later than both the widely-distributed *Sophora microphylla* and *Sophora tetraptera*, occurs on North Island's eastern side. (Inset photo)

Autumn food sources for bird migration

Figure 106: Makomako, wineberry (*Aristotelia serrata).* HJ

J Janssen

Wineberry flowers in spring and female trees fruit from late spring to autumn. Pioneering tree. It readily establishes on most soil-types.

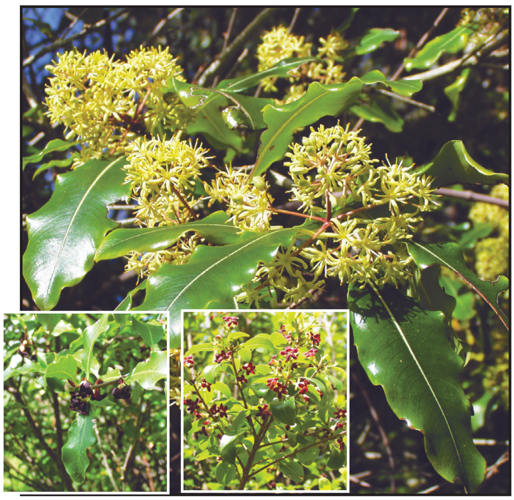
Figure 107: Karamu (*Coprosma robusta).* J.Janssen

A female karamu with last year's fruit and immature fruits and flowers (below) The insetted figure shows a male karamu plant's pollen-bearing anthers. Karamu are important native pioneering shrubs which readily establish on most soil types.

Figure 108: Coastal ngaio (*Myoporum laetum*). HJ

Leaves and bark. Pioneering tree adapted to exposed coastal conditions, which readily establishes on most soil types.

Figure 109: Common pittosporum: Lemonwood *(Pittosporum eugenoides)*; Kohuhu *P. tenuifolium* and *P. colensoi.* HJ



Pittosporum flowers aromatically and attractively in spring; Seed capsules containing sticky gluten ripen from late summer through autumn, sometimes persisting into winter. Pioneering tree which readily establishes on most soil-types.

Stock management

Check fencing intactness and effectiveness of stock being excluded from your bush patch. Stock exclusion effectiveness is assessed by comparing animal sign and browse marks on native indicator plants at the forest edge and in the understorey. Score accordingly.

Farmers have sheltered stock in native bush in the past. However, stock browsing and trampling of native bush is unsustainable, as explained in the previous chapter. Suggestions for more appropriate stock shelter and uses of compatible exotic trees on the farm can be found in 'Part 2: Resilient Landscapes' (page 119 onwards) and the Appendices Table 14, page 143–146.

Figure 110: Titoki (*Alectryon excelsus*) browsed and battered. HJ

Figure 111: The end of a lineage? HJ

Fencing can restore a more degraded bush within a decade.

Animal pests

Predators, browsers and omnivores can all be present in a forest margin. Magpies may be seen or heard.

Predators of the forest edge include mustelids (weasels, stoats, ferrets), cats and dogs. Omnivores include possum, pigs, hedgehogs, and rodents (rats and mice). Look for animal pest signs and native indicator birds and invertebrates. Native indicator animal absence shows pressures from introduced predators, omnivores and habitat loss. Score native animal presence on Table 25, page 183.

The larger the native forest, the more likely it is that absences of indicator birds (for example tomtits) are directly attributable to animal pest pressures. The smaller the native bush, the less likely you will find any indicator birds and the more important will be your assessment of invertebrate indicator species (such as weta) to determine animal pest pressures. Absence of most native animals tells you that predator/omnivore control is necessary.

Score 1 for each animal pest category (predators, omnivores, browsers) that is not present or is effectively controlled.

Contact DoC or your Council to set up tracking tunnels, possum trap catch monitoring, and initial pest control.

Browsers

Browsing animals kill regenerating young trees of the forest edge, proliferating instead less palatable environmental and economic plant pests. The main forest edge browsers are goats, deer, horses, possums, cattle, sheep and horses. As well as eating leaves, some browsers, like goats, deer, and cattle ringbark regenerating trees. Look out for animal signs, including:

- deer campsites, flattened grass in sheltered, isolated places
- animal footprints in muddy places
- animal droppings
- bite marks on leaves and bark of indicator understorey plants.

Ungulates and possums share preferences for most trees, except for totara, which is eaten by possums but left by all other browsers. Totara browse marks therefore indicate possum abundance.

Kotukutuku, fivefinger and pate are edge plants where possum or deer browse can be identified by their different bite marks in leaves. Possums leave ripped browse marks. Kotukutuku shed all or most of their leaves every winter, so any damage indicates immediate pest pressure.

Figure 112: Fallow deer hoof prints.

Figure 113: Kohekohe (*Dysoxylum spectabile*).

Possum browse damage on a coastal forest indicator plant.

Figure 114: Mamaku (*Cyathea medullaris*).

Table 6: Native plants that indicate animal pest presence	
Animal pest indicator plants	*Predominant threats*
Makomako, wineberry (*Aristotelia serrata)*	Possum, goats
Kohekohe (coastal) (*Dysoxylum spectabile)*	Possum, deer, goats
Kotukutuku (tree fuchsia) (*Fuchsia excorticata)*	Possum, deer, goats
Mahoe (whiteywood) (*Melicytus spp)*	Possum, deer, goats
Fivefinger (*Pseudopanax arboreus; P. colensoi)*	Possum, deer, goats
Mamaku (*Cyathea medullaris)*	Possum
Melicope (*Melicope simplex)*	Possum
Muehlenbeckia (*Muehlenbeckia australis)*	Possum
Houhere (lacebark) (*Hoheria populnea)*	Deer, goats

Incompatible exotic plants and plant pests

Incompatible exotics distinguish themselves from compatible ones in that they will compete with natives for space and replace native ecosystems over time.

Plant pests are defined as having serious adverse effects on desirable plants and native ecosystems. Their effect on native species is observable and can be studied (see Figure 115); the effects of incompatible plants are not so easily observable as they adversely affect native ecosystems over much longer time frames. For example, tree species adapted to surviving and regenerating after devastating bush fires in Australia and North-West America are incompatible with New Zealand's forest ecosystems. Fire annihilates native trees, regeneration and seed sources.

The 'incompatibility' status is based on analyses of species' survival strategies in their natural habitat. They out-compete a whole suite of native species in their adaptation to prolonged extreme conditions, such as cold or dry periods and tolerance of fire, shade or both. Fire-adapted species, such as eucalypts and pines, shed flammable litter. These accumulating fuel-loads eventually burn, thus maintaining favourable conditions for their light-demanding progeny. A fire effectively restarts a natural succession excluding most native plant species, thus competing with our native

Figure 115: Forest edge regeneration hindered by bindweed infestation (Convolvulus, *Calystegia silvatica*). HJ

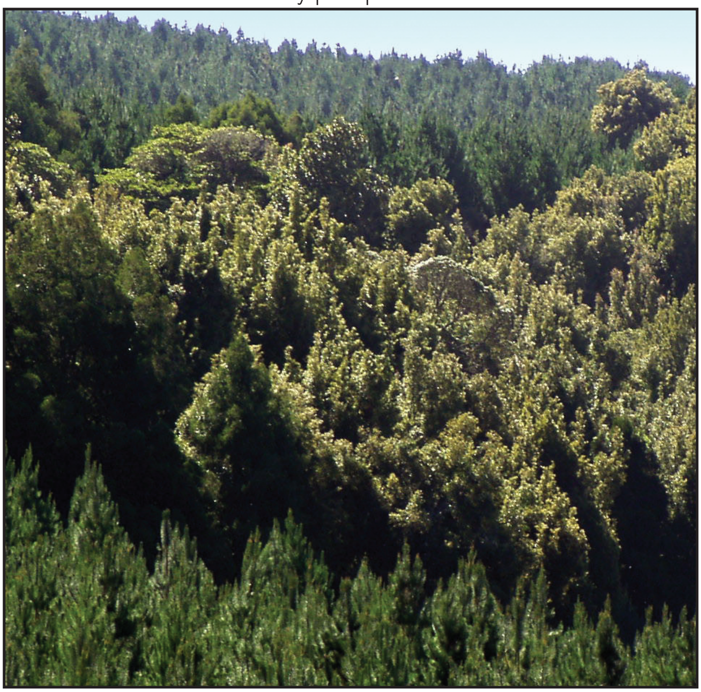
Criterion score 0, Table 24, F7; page 182.

ecosystems for space over time. These 'fireclimax' species commonly replace species and their progeny that are not adapted to regular bush fires. The dominance and expanding distribution of eucalypts in Australia and elsewhere, and the extent, both in latitude and altitude, and persistence of pine and Douglas fir conifer belts in North America demonstrate this.

Some exotic species are capable of regenerating within native forests. A combination of shade, cold tolerance and fire adaptation is particularly problematic for the future of most New Zealand native forest ecosystems, as the exclusive competitive dominance of a few conifer species (*Pseudotsuga, Tsuga, Thuja,* and *Abies spp*) in the forests of North America's west demonstrates. Such incompatible exotic plants and their progeny have the potential to invade native habitats, replace native species and eventually take the place of our unique native ecosystems.

Any of the following incompatible species (Table 7) within seeding distance of a native bush patch or its edge therefore scores nil on Table 24, F7 (page 182).

Figure 116: Fire and desiccation hazard for native bush, enclosed by pine plantation. HJ



Criterion score 0, Table 24, F1; page 182.

Table 7: Incompatible exotic plants and pests (with native ecosystems)	
Invasive fire-adapted trees (mostly fire and wind-dispersed seeds)	
Pines (*Pinus spp)*	Adapted to fire regeneration and most soil conditions. Displaces open native tussock and alpine ecosystems. Displaces native forest ecosystems under droughty and windy conditions.
Eucalypts (*Eucalyptus spp)*	Adapted to fire regeneration and most soil conditions. Displaces open native tussock and alpine ecosystems. Displaces native forest ecosystems under droughty and windy conditions.
Hemlocks (*Tsuga spp)*	Shade-tolerant, adapted to fire regeneration. Displaces native ecosystems.
Douglas fir (*Pseudotsuga menziesii)*	Shade-tolerant, adapted to fire regeneration. Displaces native forest and tussock ecosystems.
American cedars (*Thuja spp)*	Shade-tolerant, adapted to fire regeneration. Displaces native ecosystems.
Shade-tolerant incompatible and pest plants	
Trees (mostly wind and water-dispersed seeds)	
Firs (*Abies spp)*	Invasive. Compete with native ecosystems.
Sycamore (*Acer platanus)*	Invasive. Compete with native regeneration.
Sugar maple (*Acer saccharum)*	Invasive. Compete with native regeneration.
Northern beech (*Fagus spp)*	Dispersed by rodents. Compete with native regeneration.
Yellow poplar (*Liriodendron tulipifera)*	Invasive. Compete with native regeneration.
Yew (*Taxus spp)*	Invasive (bird-dispersed seeds). Compete with native ecosystems.
Shrubs (mostly bird-dispersed seeds)	
Australian white monkey apple (*Acmena smithii)*	Invasive. Compete with native regeneration.
White bryony (*Bryonia cretica; sbsp dioica)*	Invasive. Compete with native regeneration.
Holly (*Ilex spp)*	Invasive. Compete with native regeneration.
Darwin's barberry (*Berberis darwinii)*	Invasive. Compete with native regeneration.
Chinese tree privet (*Ligustrum lucidum; L. sinense)*	Invasive. Compete with native regeneration.
Evergreen buckthorn (*Rhamnus alaternus)*	Invasive. Compete with native regeneration.
Woolly nightshade (*Solanum mauritianum)*	Invasive. Compete with native regeneration.
Jerusalem cherry *(Solanum pseudo -capsicum; S. diflorum)*	Poisonous. Compete with native regeneration. Its abundance indicates browsing pressure.
Grey willow, Crack willow and hybrids *(Salix cinerea; S. fragilis)*	Overgrows native wetlands (Dispersal wind, water, vegetative)

Ground cover plant pests Shade tolerant and invasive (vegetative dispersal)	
Wild ginger, Kahili ginger (*Hedychium spp)*	Bird dispersed seeds/vegetative spread. Prevent regeneration of many native plants.
Tradescantia (*Tradescantia fluminensis)*	Prevent regeneration of most native plants (vegetative dispersal).
Climbing plant pests (seeds dispersed by wind and water; some by birds)	
Madeira vine (*Anredera cordifolia)*	Prevent forest-edge regeneration. Overgrow forest edge and clearings, may lead to canopy collapse.
Cruel or Moth plant (*Araujia sericifera)*	Prevent forest-edge regeneration. Overgrow forest edge and clearings, leading to canopy collapse.
Climbing asparagus *(Asparagus scandens)*	Shade-tolerant invasive (bird dispersed seeds). Prevent regeneration and strangles some native plants.
Old man's beard* (*Clematis vitalba)* deciduous compound leaf with 5 leaflets	Prevent forest-edge regeneration. Overgrow forest edge and clearings, leading to canopy collapse.
Cathedral bells (*Cobaea scandens)*	Prevent forest-edge regeneration. Overgrow forest edge and clearings, may lead to canopy collapse.
Morning glory (*Ipomea spp)*	Prevent forest-edge regeneration. Overgrow forest edge and clearings
Japanese honeysuckle (*Lonicera japonica)*	Prevent forest-edge regeneration. Overgrow forest edge and clearings
Banana and blue passion fruit** *(Passiflora mollissima; P. caerulea)* 3 and 5 lobed leaves; yellowish fruit	Prevent forest-edge regeneration. Overgrow forest edge and clearings, may lead to canopy collapse (Dispersed by birds and mammals)
Ivy (*Senecio mikanioides; Hedera helix)*	Shade-tolerant invasive. Senecio is a wind dispersed forest edge climber; Hedera is bird-dispersed, climbing tree trunks, not canopies. Prevent regeneration of some native plants

Distinguish from related, non-invasive natives:

* Native clematis Puawananga (compound leaf with 3 leaflets) the large white flowering *C. paniculata* and the yellow flowering *Clematis foetida*.

** Native passion vine (*Passiflora tetranda*) shiny single leaves and bright orange globular fruit.

Figure 117: Old man's beard (*Clematis vitalba*). HJ

PART 1: VISUAL BUSH SCORE

Native animals

Native animals

Sustaining bush vitality

Native animals keep our native bush healthy. Native keystone birds distribute native plant seeds, pollinate flowers and keep a check on invertebrate numbers. Other keystone animals (some insects and reptiles) pollinate flowers, while the beech scale insect provides birds with energy over winter. Score their pressence on Table 25, G1, page 183.

Indicating habitat intactness

Many native animal populations are under siege. Robin, tomtit, rifleman, bellbird, kakariki, kaka, kiwi, and brown teal and fernbird in wetlands, indicate that predators and omnivores haven't established yet or that their control is effective. Indicator animal absence points to high animal pest pressures on native animals and the need for predator control.

The larger the native forest, the more likely it is that absences of indicator birds are directly attributable to animal pest pressures. The smaller the area of native bush, the less likely you will find any indicator birds and the more important will be your assessment of invertebrate indicator species, Table 25, G2 page 183, to determine animal pest pressures.

Get advice on predator control from your Regional Council or the Department of Conservation. Ask for tracking tunnels to establish presence and abundance of predator species and for support with their control.

Pressures come from predation (mustelids, cats, possums, rats), competition by pests (magpies, introduced wasps) and because many native forest remnants are too small and isolated to sustain native populations. Once common, mainland birds including kokako, saddleback, stitchbird survive in intensive care and offshore. Maverick huia along with one third of New Zealand's original bird fauna are extinct. Many more may follow unless native bush resilience is restored.

Scoring

You can commonly hear or see native birds in flight as you walk through the bush, scoring the other sections. Birds inhabit all bush storeys, while invertebrates and reptiles are more easily observed in the understorey and regenerating bush. Birds and other native animals are best observed and recognised as you sit still for a few minutes or walk slowly. Listen and observe, and once clearly identified, score a bird species' presence, using Table 25, page 183. Early spring to the end of January are the best times to observe resident native birds, since most will have nests and established territories. At other times bird presence may be seasonal, especially in smaller bush patches, as the birds may migrate to different food sources through the year – a good reason to repeat the assessments periodically. Interpret your animal scores in relation to the native bush patch scores (see page 98).

Native species sustaining bush vitality

Vertebrate keystone species

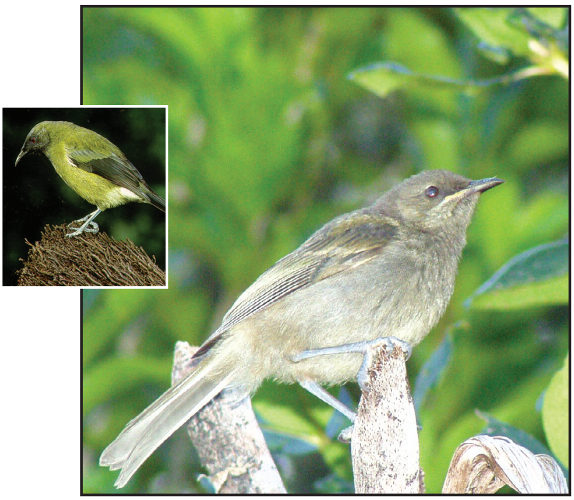
Figure 118: Kereru
(*Hemiphaga novaeseelandiae*).

Wood pigeons are seasonal migrants, capable of reaching native forest remnants that are within sight of one another. They disperse the larger seeds of miro, matai, tawa, hinau, pigeonwood and karaka. Voice: a subdued 'goo' or 'ooh'. Sound of wings in flight distinctive.

Figure 119: Tui
(*Prosthemadera novaeseelandiae*).

Tui can migrate to reach forest remnants that are within sight of one another to pollinate kowhai, kotukutuku and harakeke (flax). Tui are key dispersers of smaller native plant seeds outside their native bush patches. Both sexes look identical. Bell-like voice and guttural squawks.

Figure 120: Korimako, bellbird
(*Anthornis melanura*). HJ



Bellbirds are our most effective native plant-pollinating birds, since habitat loss and predation drove stitchbirds to extinction. They effectively disperse seeds of many native trees and shrubs in their habitat. The upper forest storeys are bellbirds' preferred habitat niche. Daytime call resembles tui but notes are more pure and contain fewer guttural sounds. Their nests are predated upon by mustelids. Female stays within 5km of forest territory. Isolated forest populations are doomed without corridor connections.

Figure 121: Hihi, stitchbird
(*Notiomystis cincta*).

Photography by Woolf

This bird's opportunistic habit was of great value to native plants, since it supported their outcrossing via pollination and seed dispersal. As such it played a major role in the ecology of podocarp broadleaf forests. A return of hihi populations to the mainland is therefore highly desirable.

Vertebrate keystone species

Figure 122: Silvereye
(Zosterops lateralis). R Morris, DOC

Adapted to native and exotic plants. This versatile bird feeds on insects, fruit, nectar. Large flocks seek food sources outside the breeding season and contribute to small fruit dispersal.

Figure 123: Wellington green gecko
(*Naultinus elegans)* on manuka. R Morris, DOC

GR Parrish, DOC

Common gecko (Hoplodactylus maculatus)and skinks (Cyclodina spp and Oligosoma spp) Some pollination and seed dispersal.

Invertebrate keystone species

Figure 124: Important insect
pollinators. HJ

Hoverflies (*Helophilus spp*) on *Metrosideros perforata*. Native bees (*Colletidae*, *Halictidae*), Blossom fly (*Dilophus nigrostigma*). Exotic bumble bees (*Bombus spp*), pollinate flowers under adverse weather conditions.

Figure 125: Beech coccid, scale insect
(Ultracoelostoma assimile). J. Janssen

Energy supply for birds, reptiles, insects and nitrogen-fixing mould.

Indicator species of habitat intactness

(Good habitat size; community composition, low pest pressure)

Figure 126: Robin
(*Petroica australis*).

Robins are inquisitive territorial birds of the forest interior. They don't travel far and those found in isolated native forest remnants are direct descendants from ancestors that survived the time of bush clearance. Robins give a good indication of the life-supporting capacity and pest pressures on native forest remnants. Song is a plaintive tweep tweep leading to a slow warble.

Figure 127: Tomtit
(*Petroica macrocephala*).

Tomtits are birds of the forest interior. Tomtit populations found in isolated native forest remnants descend from ancestors that survived the time of bush clearance. Tomtit populations give an indication on the life-supporting capacity and pressures on native forest remnants. Call: 'ti oly oly oly oh'.

Figure 128: Kaka
(*Nestor meridionalis*).

Kaka are at home in old growth podocarp-broadleaf forest and preferably nest and feed in large emergent podocarps and canopy trees. Nesting females and fledglings are very susceptible to predation. Kaka can be conspicuous when in a flock, but cryptic when feeding alone, the sound of falling pieces of bark often betraying their presence. Their calls are a wide variety of liquid whistling notes and harsh, grating calls.

Figure 129: Kakariki, parakeets
(*Cyanoramphus spp*).

Red and yellow crowned parakeets may be found in or near the Ruahine Ranges and central North Island forests. Parakeets have become rare since cats, rats and stoats spread throughout New Zealand. They fly considerable distances to reach food sources. In flight, their call is a rapid chatter: 'ki-ki-ki-ki-ki'.

Figure 130: Kiwi
(*Apteryx australis*).

Kiwi are seldom seen but their penetrating calls can be heard for miles. Call rates are highest in the 2 hours after dusk and before dawn. The male call is a drawn-out ascending, shrill whistle note, repeated 15-25 times. The female call is a hoarse, guttural note repeated 10-20 times (Heather and Robertson, 1996).

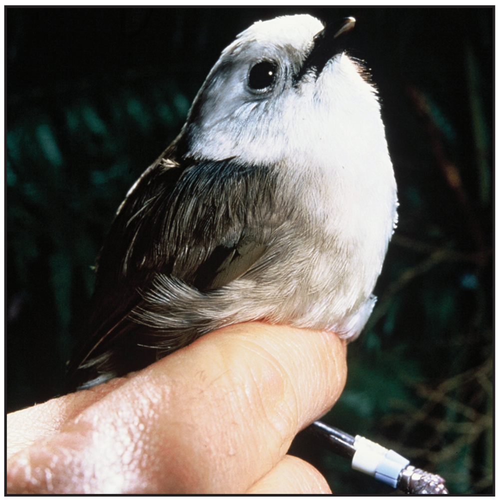
Figure 131: Kokako
(*Callaeas cinerea*).

Avian 'squirrel'. Very rare. Released from island refuges near the Pureora ranges.

Figure 132: Titipounamu rifleman
(*Acanthisitta chloris*). MF Soper, DOC

New Zealand's smallest forest bird. The flight is short from tree to tree, where it probes for insects. Occupies same territory throughout the year. Builds new nests each year in tree holes. Call: high-pitched *sipt, sipt*.

Figure 133: Whitehead
(*Mohoua albicilla*). D Veitch, DOC



Prefers to breed in beech or kanuka forests, at times polygamous. Social bird, moving into podocarp forest over winter. Once common, now much reduced – can persist in isolated bush patches. Eats insects, seeds and fruit from ground level to canopy. Contact note a single *cheet, chip or zit*.

Figure 134: Fernbird
(*Bowdleria punctata).* R Morris, DOC

Wetland bird. Secretive small bird with fern-like tail feathers. Nests amongst rush, raupo, flax and woody shrubland. Short metallic sounding calls, such as *utick, tcherp, zrup, tchick, teeoo.*

Figure 135: Brown teal
(*Anas aucklandia).* D Veitch, DOC

Wetland, flax and kahikatea swamp forest teal. Once common in these habitats, but also in estuaries and forest. Now rare due to habitat loss and predation. Small dark-brown duck. Roosts in flocks outside breeding season.

Figure 136: Short-tailed bat
(*Mystacina tuberculata*). D Veitch, DOC

The only native mammal with a long lineage in New Zealand. The other native long-tailed bat is regarded as a more recent immigrant.

Figure 137: Short-tailed bat
(*Mystacina tuberculata*). BD Lloyd, DOC

Short-tailed bat roost near Ohakune.

Invertebrate indicators of habitat intactness

Figure 138: Green stick insect on karamu.
R Morris, DOC

Brown, spiny and green, (*Phasmatodea spp*) stick insects feed on tree and shrub leaves by night, hiding along branches and twigs by day.

Figure 139: Brown stick insect.
D Veitch, DOC

Figure 140: Weta (*Anostostomatidae*). J Taylor, DOC

Different habitats can host ground weta, giant weta, tree weta or cave weta.

Figure 141: Peripatus.
D Gleeson, DOC

New Zealand's 'living fossil', peripatus can be found hunting in leaf litter and hiding under decaying wood. Also keep a look out for giant land snails (*Powelliphanta spp; Placostylus spp*) There are numerous endemic site-specific species. Snail shells often betray possum and rat predation.

Exotic birds

Most exotic birds prefer forest edge, open woodland and grassland habitats, where their main diet includes invertebrates, seeds and fruits. Native and exotic bird habitats overlap in the dynamic and productive forest edge zone, from where both significantly reduce potential agricultural insect pests and contribute to the dispersal of fruit-bearing native and exotic shrubs and trees.

The blackbird (*Turdus merula*) readily inhabits interior native forest, potentially increasing competition for resident native bird populations, while facilitating native seed dispersal within and outside native bush. Most bird-dispersed exotic plant pests are light-demanding forest-edge shrubs and pose little danger to a structurally intact native forest patch. Exceptions are the shade-tolerant and bird-dispersed plant pests.

Some exotic birds (e.g. magpies) compete with and displace native birds in their forest habitats by raiding their nests. Their presence should be noted in the bush diagnosis and their removal become part of the animal pest control part of the bush management strategy.

Exotic birds can have both positive and negative effects on the ecological processes of native forest patches; the relative weighting of which has so far not been established by research in New Zealand. Accordingly, you do not score this component, but note your observations in the bush diagnosis, writing down exotic bird species observed.

Differentiate sighting a few birds (1–4 birds) from a flock (more than 4 birds of one species).

This completes the field survey.

You should repeat the survey regularly, and also at different times of the year, to recognise the differences between the seasons.

D Crouchley, DOC

Please visit www.bushvitality.org.nz,
www.bush.org.nz,
and www.landcare.org.nz to:

- Help you assess your bush remnant's vitality,
- Develop your bush-restoration, sustainable farming strategy.

Ace V Janssen-Rich

PART 1: VISUAL BUSH SCORE

Scoring bush vitality


HJ

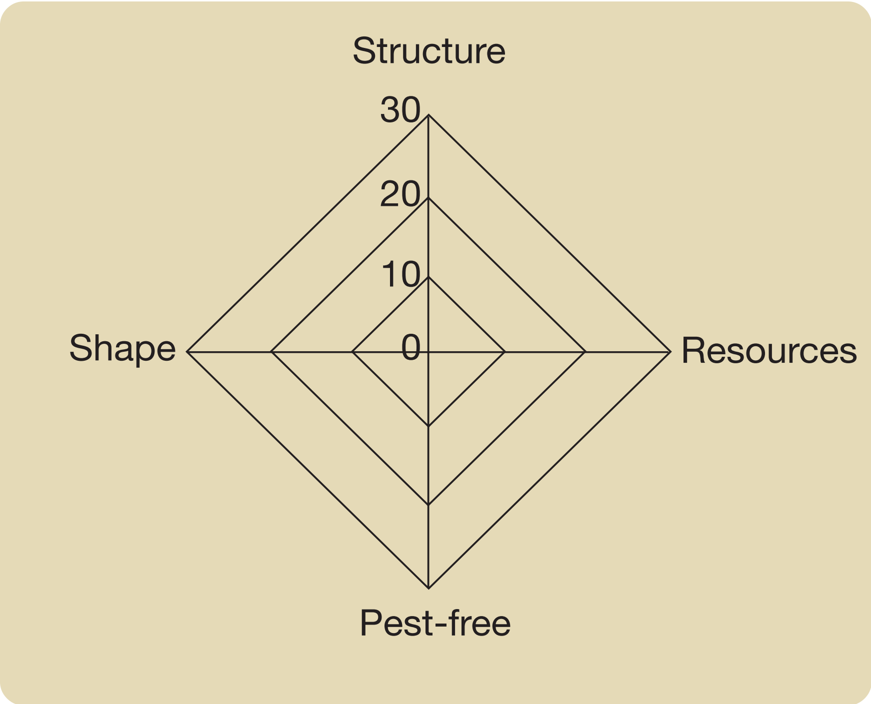
Bush results

You now need to bring the scores together to get an idea of the bush patch vitality. Enter the summary scores for each category from Table 26, page 184 and calculate the scores and graph:

- shape (spatial integrity)
- food resources
- forest structure
- pest pressure.

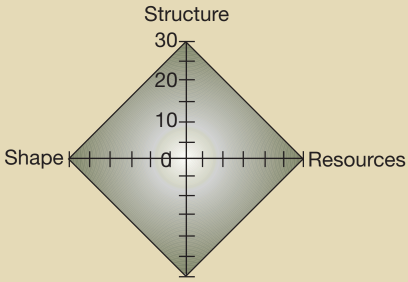
Categories associated with these summary scores can be improved upon as you diagnose the state of the site's vitality (see Figure 145, page 99) and implement your bush management strategy. Native animal populations will flourish naturally where the diamond assumes a perfect shape.

Figure 142: Chart for category summary scores.

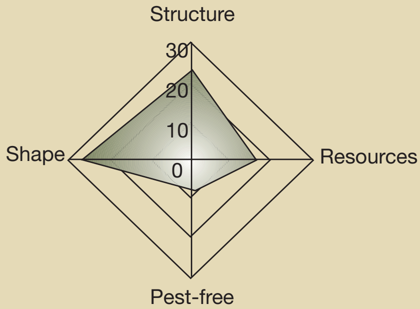


The higher the score, and larger the diamond, the better condition your bush patch is in. See examples below to help you interpret your bush patch. The scores will be approximate only – different people visiting the bush on a different day from you are likely to score differently from you, for many reasons, including different observation skills or timing. Importantly, the scores should be more or less consistent for each observer, clarifying the issues affecting the vitality of this area of bush.

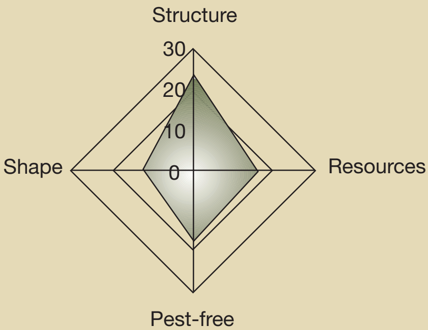
Figure 143: Example charts of bush vitality summary scores.



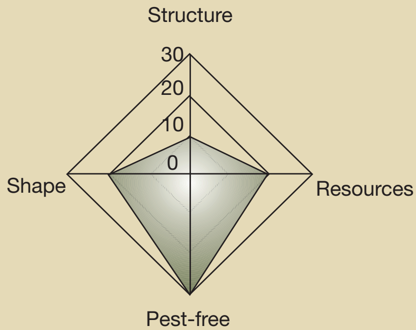
The ideal bush patch.



This bush patch is under heavy pest pressure, which is also reducing the food available for natives and will degrade its structure.



This bush patch suffers from being either remote from other bush, small size and/or lack of interior bush. Improve pest control effectiveness; fence for better shape; plant out forest edges and structural gaps with missing resources.

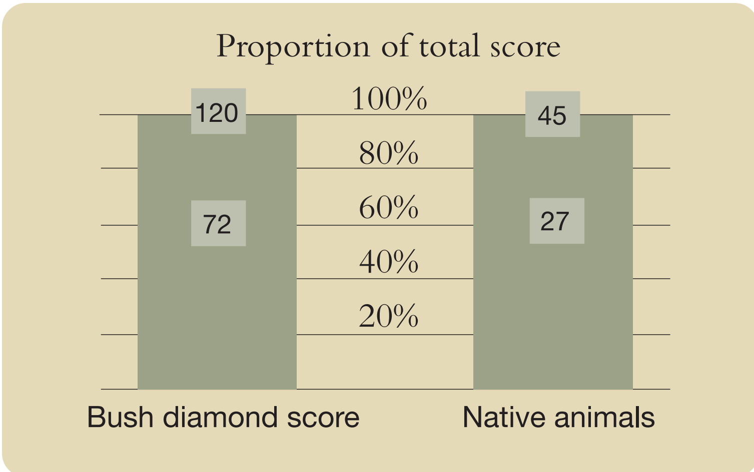


This bush is well-looked after, but has probably been logged or had stock or pests browsing it in the past. Plant up resource and structural gaps; improve its shape or connectivity to restore bush vitality.

Interpreting related scores

Low native animal numbers (Table 25, page 183) can be early indicators of longer-term decline of resident native plant populations. Provided you have assessed your native animal populations over summer and have made an effort to find them in their likely habitat, the bush diamond score and that of the native animals should proportionately be about the same (compare Table 26, page 184). They correlate well, since native plants and animals have evolved particularly close ecological links. Compare the proportions of the 'bush diamond score' totals with the 'total native animal score' from Table 26 and plot your results on the bar graph below.

Figure 144: Comparing diversity– native animals versus native plants.



The two scores should proportionally be at about the same level (for example: a 'Bush Diamond Score' of 120 and a native animal score of 45 equal 100%). Your native animal scores may be 27 (60%), corresponding to a 'fair' bush diamond score of 72. The shape of your diamond may help you pinpoint the reasons for a low animal score. Native plant populations may be at risk, where native animal scores are proportionately far below the bush diamond score and vice versa.

The bush diamond score shows the overall health, or capacity of the bush patch to sustain life, while the native animals score shows whether this capacity has been taken up or is in continuing decline.

Bush diagnosis

You have now examined your bush patch and scored its vital components. By evaluating each vital component you are effectively assessing the bush patch's strengths, weaknesses, opportunities and threats (SWOT). The 'SWOT' analysis shows you the ecological value and condition of the investigated bush patch and its vital components, giving you the basis for a sound bush diagnosis and developing a management strategy for your bush patch.

Fill out the SWOT chart (Fig 145) to help you diagnose bush vitality. Find an enlarged replicable SWOT chart with the score sheets on page 186.

Figure 145: Bush diagnosis SWOT chart.

Element	Strengths	Weaknesses
Spatial integrity		
Forest structures		
Food resources		
Pests		
Element	**Opportunities**	**Threats**
Spatial integrity		
Forest structure		
Food resources		
Pests		

SWOT analysis

Strengths

A **good** to **excellent** score means that you have examined a resilient bush patch that is most probably a key native habitat or 'habitat node' in terms of generating source populations for surrounding habitats with lesser scores.

High scores for particular vital bush components reveal particular strengths for sustaining larger scale native ecosystem functions, even where overall score is lower, indicating the bush is still important.

For example: regenerating shrub may have a low summary score because of missing bush structure, such as tall native emergent trees and incompatible exotic trees surrounding it. But high winter and autumn food source scores in the regenerating shrub component indicate this shrubby patch is an important link for migrating native birds at critical times when food sources are scarce and for juvenile birds searching for new breeding territories.

Weaknesses

You can identify bush weaknesses by assessing bush component low scores (moderate or poor). Consider component and individual scores, in relation to opportunities to develop a bush management strategy that remedies any weak links and sustains bush vitality.

Opportunities

When developing the bush management strategy, consider your site's geographical opportunities (soil types, aspect, slope, stream-corridors) in relation to short to long-term goals. Site-specific opportunities may arise from a site's topographic layout (streams, banks, clay, stony, or sandy soil) or farm features (dairy-herd tracks, farm-tracks, shelterbelts, effluent treatment woodlots and constructed wetlands for treatment of surface run-off). Remedy the bush site's weaknesses by using its identified strengths and opportunities.

New Zealanders have tended to think of forests in black-and-white terms: either as exotic production forests or conservation native bush. However, for forest and bush on private land, there is a third way where through careful active forest management the two goals can be integrated. This has been less attractive to land-owners in the past, given the quarter century financial returns on pine plantation forestry, even though pines and eucalypts are price takers (the timber processing industry determines price). However, there is now a world shortage of planted

sustainable forests. Their high quality timber products are price makers (the grower determines the timing and price of the products). Accordingly, tree cropping and timber products of highly valuable individual trees from intact and planted forests will increasingly become a viable land-use option, compare Figure 156 and Table 12, pages 134-138.

New Zealand's productive land is generally cleared and associated with unweathered, relatively fertile soils and a temperate climate with few frosts. These provide unique opportunities to diversify farm production and achieve beneficial biodiversity outcomes at the same time. Many high-value tree crops from around the world grow wherever wind shelter is established, near native bush, in a gully, next to an established row of trees, thus addressing some of the weaknesses your bush patch assessment may have identified. Plenty of opportunities exist to remedy native bush shape, size and connectivity weaknesses as integrated sustainable farming enterprises develop. As long as compatible plants are used and the treeland is managed as a permanent forest, the benefits in terms of sustaining both farm production and native ecosystem processes are undeniable (see Agroforestry, page 120).

Conservation and sheep grazing are compatible in the initial stages of totara forest regeneration, particularly where spaced poplar can train valuable totara to good form (see Reafforestation models, page 126). The farm's capital value increases as totara regenerates, while stock grazing continues. Such parkland totara forests provide shelter for stock and migrating native birds alike, providing a corridor function perpendicular to stream corridors, linking upper catchments.

Consider all opportunities as you develop your site's bush management strategy. Financial support may be available to assist implementing a well-designed strategy. Native reafforestation can also generate tradeable carbon credits to address New Zealand's global climate change commitments as native bush regeneration effectively stockpiles carbon in biomass and soil.

Threats

Having done your site assessment you will be aware of the main threats facing your bush patch. You will have already identified major threats from:

- plant pest invasion
- incompatible planting
- animal pests
- farm stock
- too small a size

List the threats in the SWOT chart for remediation when developing your bush management strategy (see page 106).

Be aware that unseen threats may lie in wait where bush patch resilience is low. Long after native forest clearance, remaining plant and animal populations are vulnerable to extinction (extinction debt). Insect and fungal pathogens can wipe out small remaining plant populations, weakened by a dry spell or gale. Small surviving animal populations can become extinct as a consequence of consistent pest pressure or climatic extremes, affecting plant and invertebrate reproduction and food availability. This is a major threat to small isolated native remnants, particularly in regions with a recent deforestation history.

Other threats to consider are adjacent incompatible fire or shade-tolerant tree plantations. Where such plantations already exist, plan for their replacement with permanent forests of compatible multiple-purpose tree species as your bush management strategy's medium to long-term goal.

PART 2: INTEGRATED MANAGEMENT STRATEGIES

Restoring bush vitality

The Living Forests of New Zealand, NZ Native Forests Restoration Trust

Native trees and their values

Scientists agree that habitat loss is a key factor in biodiversity decline and that a threshold for native ecosystem sustainability is breached where ecosystems have lost more than 80% of their original extent. New Zealand's native vegetation cover stands at 22% of its land area[7]; precariously close to the 20% threshold. Where this native ecosystem sustainability threshold is breached and biodiversity is in decline, irreplaceable native biodiversity becomes invaluable.

This threshold has been breached in most lowland and hill country environments. For example, the lower North Island's native forest ecosystems were cleared to 16% from their original near complete cover, just over one century ago. Native lowland forest and wetland ecosystems (0-400m) now cover less than 5% of their original extent.

New Zealand's economy and society rely on ecosystem services provided mostly by previous native ecosystems and existing remnants. Such ecosystem services are estimated to provide each year over 4 times the value of NZ's 'Gross Domestic Product' (compare sustainable development and the triple bottom line pages 108-110 and figure 147).

About 30% of all native forest cover is privately owned or local authority reserves. They are mostly native remnants of hill-country ecosystems (400-700m) and lowland forest and wetland ecosystems. These bush patches, irrespective of their present condition, are crucial for the long-term sustainability of native forest ecosystems.

Tree and forest remnant values are therefore increasingly measured in terms of their essential contribution to sustaining ecosystem processes and maintaining native biodiversity, rather than just in terms of timber value[8].

Up until the 1990s values of native trees and their timbers were merely a reflection of timber extraction and saw milling costs. Even plantation forestry based on versatile *Pinus radiata* had a hard time competing. The timber value of a 1000-year rimu was equivalent to that of a 25 year-old pine tree and until the late 1980s native hardwoods such as beech and pine chips were exported in equivalent quantities.

Nowadays, timber from native species is available as recycled wood or from native forest stands certified for sustainable management. The Forests Amendment Act 1993 sets out provisions relating to indigenous forests and sustainable forest management plans. However, native timber production can only be sustainable long-term where native trees are planted in addition to precarious native forest remnants[9].

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7 The Department of Conservation administers about 30% of New Zealand's natural land area, mostly native ecosystems above 700m, including mountain forest, scrub, tussock and mountaintops. This also includes about two thirds of New Zealand's native hill country (400-700m) and lowland forest remnants, the balance is privately owned or territorial local authority reserves.

8 Environmental value systems are well established overseas, particularly in relation to native forest cover and its distribution in the landscape. In evaluating NZ's 'clean green image' visitors compare NZ's forest cover and distribution with their home country. Japan's native forest cover is about 65% of its total land area; Canada (43%); Hessen region, Germany (42%); USA (32%); Germany (31%). Mixed species native forests are a common component of a long-established production landscape and forest patches are generally within cooee of one another.

9 Most people live by the saying: "one reaps what one sows" and appreciate that the era of 'the reaper' (who merely takes) is over.

Figure 146: Threshold for native ecosystem sustainability

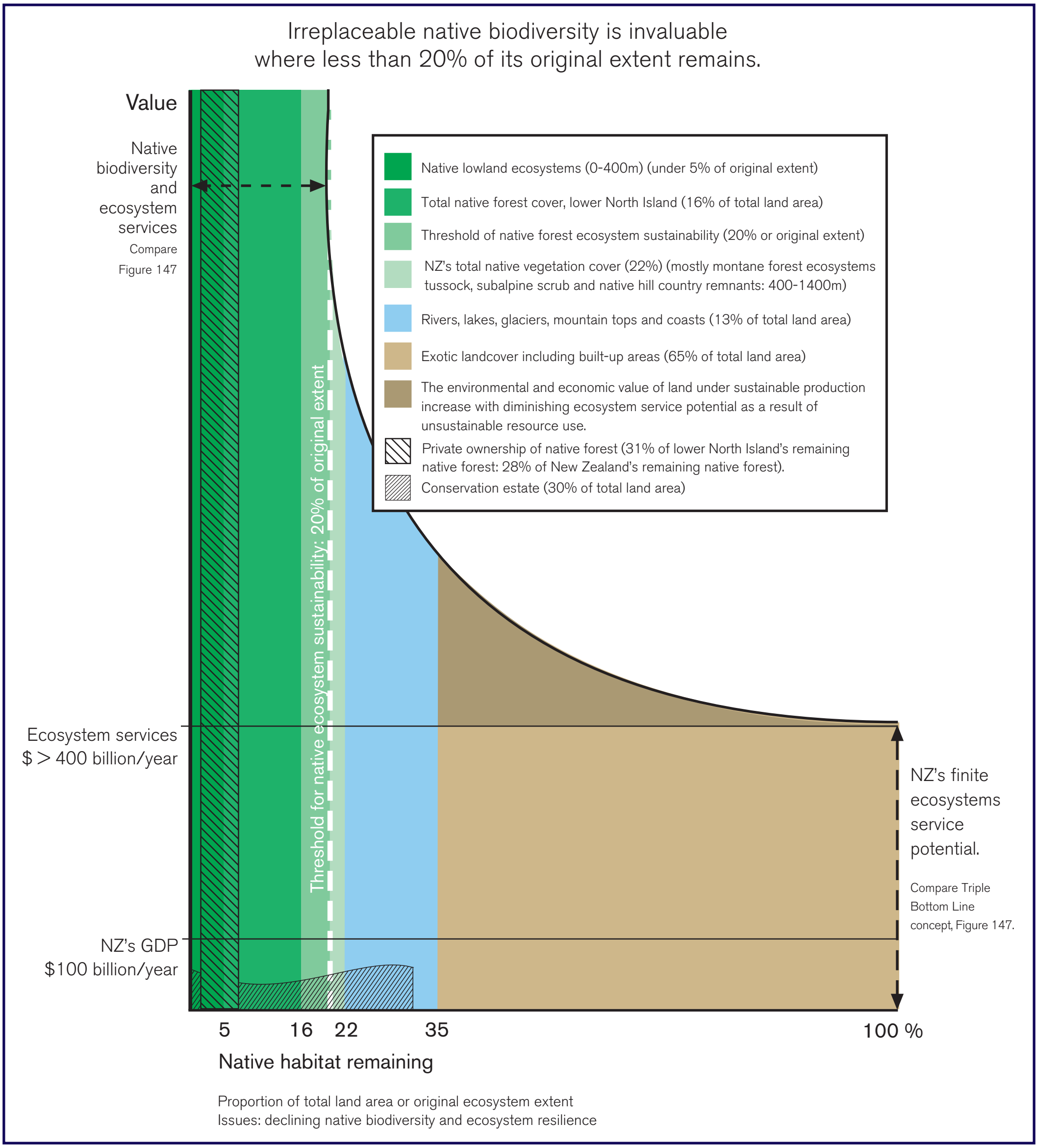


Figure 146 shows that there is an urgent need to restore native ecosystem processes to maintain native biodiversity and sustain ecosystem service potential long-term. Sustainable enterprises that re-afforest cleared land with compatible and/or native tree species can achieve this by integrating farm production and environmental protection (compare 'Resilient landscapes' chapter pages 119-138).

Bush management strategies

The ultimate goal of any bush management strategy is to integrate native and compatible exotic species within a sustainable productive landscape. This takes work and effort over time and can be helped by developing a bush management strategy consisting of plans and implementation timelines for short, medium and long-term goals:

- *short-term goals* generally focus on remedial bush protection action (stock exclusion and pest control)
- *medium-term goals* integrate sustainable farm production and bush protection objectives. They address bush patch size, connectivity issues and health of native key populations, as you secure and establish native or compatible exotic plants in suitable areas.
- *long-term goals* establish a sustainable productive farm of compatible species, integrated in resilient native ecosystems.

Contact the author, DoC, or council staff for advice and support in preparing your strategy.

Short-term goals (1-5 years)

The short-term goal is to remedy vital bush components and move the bush patch from intensive care to a state requiring preventive treatment only. Often this requires effective fencing to keep stock out, and initial pest knock-down and continued low-level maintenance control.

Pest management

You should refer to your Regional Council's Plant and Animal Pest Strategies to see whether you have listed pests, and to see what support the Council may be able to give you. You can save a lot of effort if you work with and take advantage of the Council's initiatives. Pest control priorities may differ depending on locality; for example, possums are likely to be a severe problem outside Animal Health Board TB possum control zones. Here, the Regional Council may initially control possum where stock is excluded from native forest and where there is landowner commitment to follow up possum control.

Priorities for control and eradication of environmental plant pests, like old man's beard, are highest outside pest containment areas. These areas are defined in the Plant Pest Strategies. Within a plant pest containment area it is recommended to apply the 80/20 efficiency rule[10]. This rule can achieve cost-effective outcomes

10 The Law of Diminishing Returns refers to the fact that with relatively little effort or expense much can be achieved (80%), while much effort or expense is often required to completely eradicate a pest (100%). Native bush responds well to integrated and efficient animal and plant pest control. Native regeneration can then rapidly restore bush vitality and resilience against many pests, reducing the extent of pest-control needs in the long term.

especially where eradication is not feasible. Here, the goal may be to prevent fruiting of shade-tolerant pests and to cut and herbicide-paint vines that reach and threaten the canopy or important forest edge plants, thus eliminating actual threats to existing vegetation. Particular attention should be given to prevent seeding of shade-tolerant plant pests by cutting and herbicide painting of shrubs and pulling out tubers of bird-dispersed climbing plant pests.

Coordinated plant and animal pest control is often essential. For example, following a possum or goat eradication, plant pests like banana passionfruit need to be controlled as well to prevent this plant taking advantage of reduced browsing pressure from animal pests. Coordinated pest control also slows new animal pest populations from re-establishing at the site and makes managing an 80/20 efficiency rule for pest control more cost-effective in the long term.

For pest control advice and support contact your local DoC or council offices.

Fencing for the future

Before establishing a permanent stock-proof fence, consider your medium-term goals for bush patch size and shape, including future compatible plantations and farm development. You may like to consider converting land around existing native bush into a multi-purpose forest and corridors across the farm forming multi-purpose, grazed parkland. Multi-purpose riparian corridors will stabilize riverbeds, allow the return of predominantly native plants near waterways and may be managed for timber production or other purposes provided stock remain excluded.

Medium-term goals (5-10 years)

The medium-term goal is to restore bush resilience and health by addressing patch size, connectivity to other bush patches and increasing diversity of native key populations. Activities to achieve medium term goals can begin as soon as short-term goals, such as stock exclusion and integrated pest control are completed.

Patch size and shape can be improved using buffers of native and compatible exotic tree species.

Native key species population viability is strengthened as missing and small plant populations are re-established by developing planting programmes to ensure breeding and food source continuity.

Connectivity may be improved as winter and autumn food sources are fenced or established along streams, rivers, banks, wind-shelters, farm tracks, and roads.

Long-term goals (more than 10 years)

The long-term goal is to maintain native biodiversity, as native ecosystem functions and bush patch resilience are restored within a productive landscape of native and compatible exotic plants and animals.

Permanent managed forests are established linking native remnants and providing space for regenerating native species. Here management methods developed for temperate climate hardwood forests are used, leaving the bush intact, while valuable single or small coupes of trees are harvested on a sustainable basis. Once ecosystem resilience is achieved, native biodiversity decline is halted and native species can be harvested on a sustainable basis.

Measurable farm sustainability and environmental indicators increasingly determine capital land value, rebatable ecosystem services and biodiversity values. Indicators include:

- Area covered by resilient native ecosystems
- Area covered by compatible permanent forests
- Soil quality indicators (topsoil depth, soils organic matter, soil structure)
- Water quality indicators (suitability for contact recreation, riparian corridor length)
- Carbon-sink balance (biomass and soil carbon accumulation/loss over time).

Planning this far out is less certain and some best guesses may be needed and acted on. Environmental issues are likely to remain at the forefront of public concerns, and ecosystem management may well be a good financial investment (see Figure 146). Policies to recognise ecosystem services are already being implemented in Europe and Australia[11] (compare Figure 147) and farm sustainability certificates are a likely requirement in the future to ensure access to overseas markets.

Sustainable development and the 'triple bottom line'

The triple bottom line concept refers to three key assessment criteria for sustainable development: *environmental, social/cultural* and *economic.* All three are now taken into account when deciding a project's merits.

This concept shows that any economic development must be environmentally sustainable and of value to society. Environmental sustainability is the pillar of support for both social/cultural and economic development. Advancing one (social or economic) to the detriment of another degrades ecosystem services[12] and ultimately society and its economy.

11 The value of ecosystem services delivered per year has been estimated at over 4 times the value of Australia's GDP (gross domestic product of A$1,300 billion per year) (Bateson, 2001).

12 Ecosystem services refer to the energy and resources that are available for human use and consumption, without degrading an ecosystem's potential to supply resources to future generations and other biota.

The Genuine Progress Index (GPI) measures a society's progress towards sustainability. It recognises that long-term prosperity and wellbeing is dependent on the protection and strengthening of social and environmental assets.

The GPI is being trialled in Canada, Australia and Europe and is set to replace the crude GDP Index which does not distinguish between sustainable and unsustainable practices such as pollution and crime (refer to Appendix, Information Source, internet information, Genuine Progress Index).

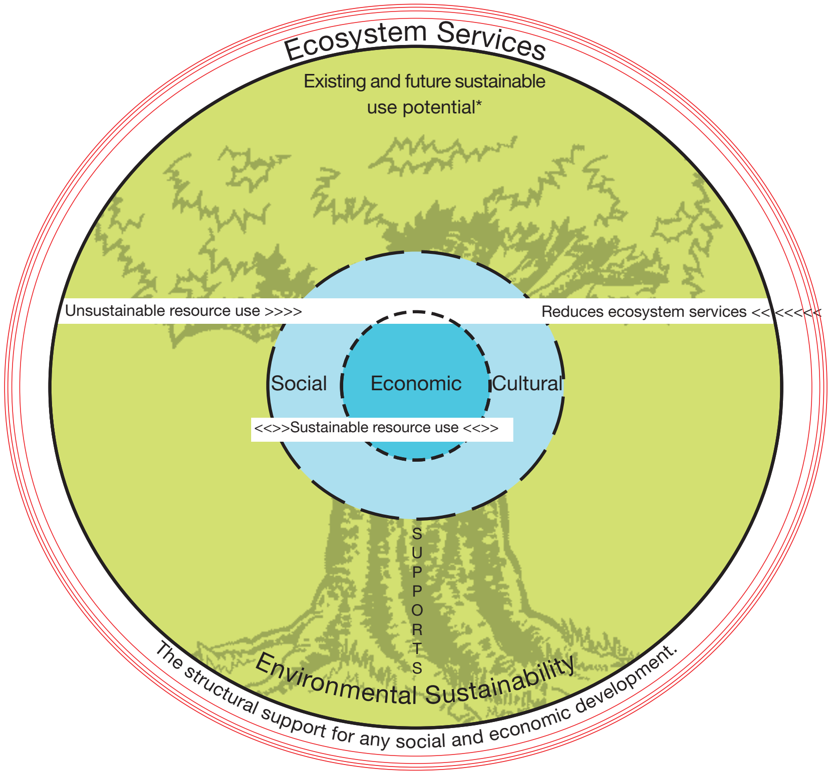
Recent human history is one of unsustainable resource use and exploitation. Colonisation of new lands and resources gave the illusion that a constantly expanding economy, feeding on newly available, as well as fossil ecosystem services was sustainable. People now realise that where ecosystem-service-potential degrades, as a consequence of unsustainable resource exploitation, civilised social and economic systems cannot endure.

New Zealand's and this planet's resources and ecosystem-service-potential are finite. Economic and social spheres' development relies on qualitative growth and renewable resources being used more efficiently. The alternatives are resource wars and a dire future for human civilisation. Sustainable development agreements made by world leaders in Rio 1992 and New Zealand's Resource Management Act result from this realisation.

The following graphic (Figure 147) shows that:

1. Ecosystem services are finite (solid line) and their potential to sustain society and economy is determined by:
   - Substrate qualities (nutrient content of rocks and storage capacity of soils)
   - Latitude (solar energy input and water availability)
   - Ecosystems' productivity and efficiency in storing, cycling and exchanging nutrients, water and energy
   - Ecosystem resilience
2. Resilient cultural/social and economic spheres are nested and evolve within an environment's ecosystem services capacity. Growth is associated with sophisticated productivity, cultural reassociation and quality outputs as renewable resources are efficiently used and non-renewable resources are effectively cycled and reused.
3. Resource exploitation an environmentally unsustainable management lead to environmental and social/cultural degradation and is neither socially nor economically tenable.

Figure 147: The Triple Bottom Line concept.



* Ecosystem services include:
Water filtration, storage and flood control (regulation of flow)
Efficient biotic and soil nutrient storage, cycling and exchange, soil formation
Ecosystem resilience and processes that sustain irreplaceable native biodiversity
Carbon sequestration, climatic ambience, pharmaceuticals, biotechnology etc.
Tourism; recreation; amenity values
Prehistoric: fossil fuels, ores

Summary

You have now taken your native bush's pulse (scored its vital components), diagnosed its ailments (SWOT analysis), and developed a prescription and recovery plan (bush management strategy). The next chapters introduce you to established know-how and techniques that support your recovery plan's implementation. They can be 'triple bottom line approved'; enhancing ecosystem service potential, developing a strong and resilient economic base and a multi-skilled, more integrated society.

Restoration planting for bush resilience

A wealth of knowledge about native bush restoration and management is available for you to use. Some resources to investigate are listed in the Appendix. They include your Regional Council, Department of Conservation, the Crown research institutes and the QEII National Trust, Landcare Trust and Tane Tree Trust, among others. Information is available on their websites, or in publications available for purchase or from your library. As well, other landowners in your area may already be caring for their bush patches, and will have good local information – and moral support and enthusiasm – to help you. View the Bush Vitality website to establish contact and exchange information.

The best plants for the place

For best and most satisfying results, you need to match any plants with the environmental conditions they are best adapted to.

Compatible root-systems

Combining plants with different root systems can have considerable advantages over covering a site with a single plant species. Root systems with diverse shapes and structures from either native or compatible exotic plants can more effectively access and cycle soil nutrients, protect river margins (see pages 112–118) and stabilise slopes (see pages 123–125).

Plate-rooting plants have shallow horizontal root systems and reduce topsoil loss from scouring. Tap and heart-rooting trees stabilize soil on slopes and can prevent undercutting on riverbanks. Each root system type carries out a different but complementary function. Together they effectively protect riverbanks and maximise the regenerative capacity and productivity of a forest ecosystem.

TYPICAL ROOT SYSTEMS OF SOME NATIVE AND EXOTIC PLANTS

1. **Plate-rooting plants** (wide-ranging surface roots) include:
   - NZ flax, kahikatea, pukatea, hard beech, black beech;
   - Willow, (some plants adapt to marginal sites by growing plate roots[13]).
2. **Tap-rooting plants** (central leader sinker-root) include:
   - Totara, kowhai, rata, black maire;
   - Walnut, hickory, chestnut, oaks.
3. **Heart-rooting plants** (heart-shaped root-system with several sinker-roots) include:
   - Lemonwood, kohuhu, cabbage tree, kanuka, manuka, broadleaf, ngaio, puriri, rewarewa, tawa, rimu;
   - Red, grey, black alders[14] ash, maples, poplar, hazelnut, rowan, mulberry, elm.

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13 Many typically heart-rooting plants (for example ash, poplars, maples, rowan) can adapt to very dense or waterlogged sub-soils by forming plate-roots.

14 Black alder (*Alnus glutinosa*) roots readily penetrate waterlogged soils and can stabilise swampy riverbanks as they effectively prevent undercutting.

Plants for river, lake and stream margins.

Margins of streams, lakes and rivers provide natural regeneration space for many native plants. Fencing these areas off keeps stock out of waterways and will eventually allow natural regeneration from nearby remnants to cover bare soil, grass and willows.

For more immediate results plant locally sourced natives on sites they are best adapted to. Consider re-introducing native plants where native remnants are too distant (about 2 kilometres, or beyond "cooee"). Always propagate native plants from seeds collected from neighbouring and equivalent native sites (eco-sourced plant seeds).

The following river and stream-bank profiles (Figures 148-150) show typical native plant associations of river and stream margins. Decide upon the profile that best represents your site and be inspired by the range of suitable native plants. The margin's side that faces your productive land can usefully be planted with multi-purpose native or compatible exotics plants to enhance corridor resilience and productivity (compare 'Agroforestry' (pages 120-122), Table 13 (pages 140-142), and Table 14 (pages 143-146)).

The profiles (Figures 148-150) are guides to help you decide which native plants to place where. They show a plant's preferred place along the (riparian) river margin. The numbers in the river and stream profiles' plant silhouettes link to plants typically found at lowland riparian margins in central New Zealand (refer to the 'key' column on Table 8 (pages 114, 116-118)).

The table's central columns contain common and scientific plant names. Common plant names in **bold print** can be planted first on open ground. Plants in bold print, followed by an asterisk (*), indicate early succession plants that can be planted in large numbers, because of their rapid establishment and wide-ranging environmental tolerance. The right-hand column, 'Conditions – where to plant', contains a brief summary of a plant's preferred site along the riparian gradient.

Tall emergent and canopy plants are listed first (page 114), followed by 'subcanopy trees and shrubs' (pages 116-117). 'Groundcover plants and climbers' are listed at the end of Table 8 (page 117-8).

Figure 148: Typical river profile.

This river has an over-steepened bank on the left with a broad flood-plain sequence on the right.
The scale is exaggerated.

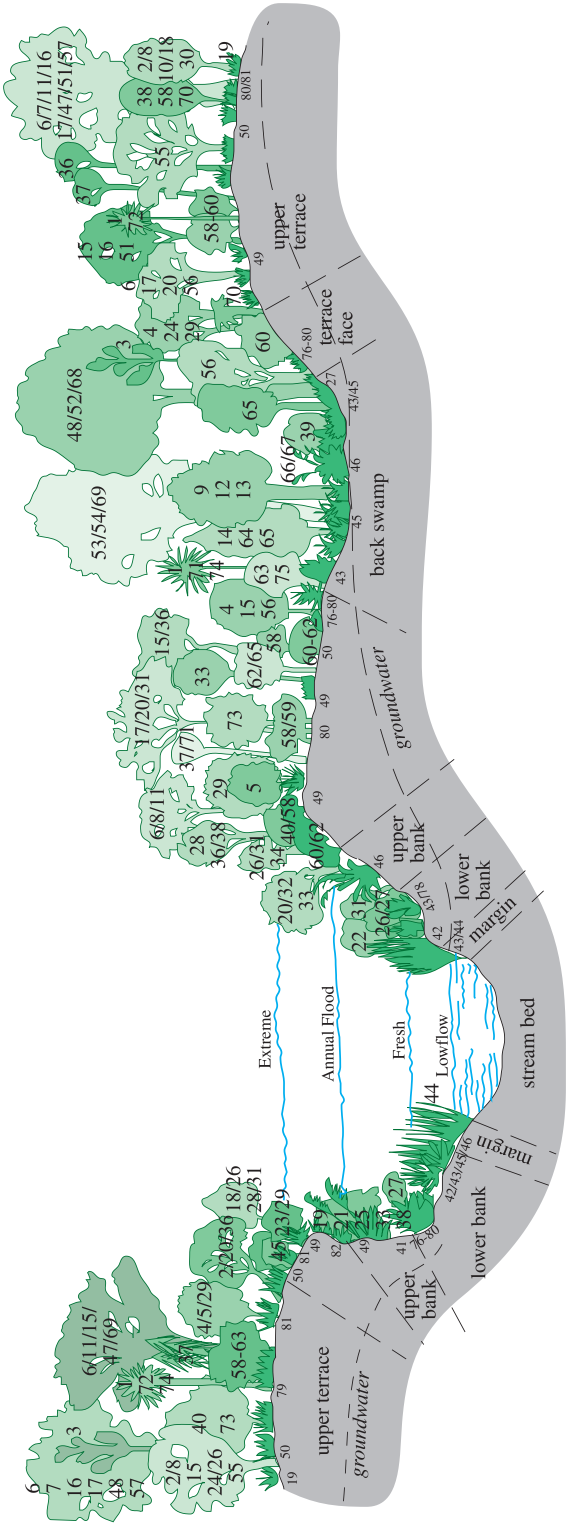


Table 8: Planting guide for native plants common in central New Zealand			
Tall emergent, canopy, subcanopy trees			
Key‡	*Common names*	*Species name*	*Conditions – where to plant*
1	**cabbage tree, ti kouka***	*Cordyline australis*	Anywhere except in dense shade.
2	**kanuka***	*Kunzea ericoides*	Free draining soil, in the open.
3	**rewarewa**	*Knightia exselsa*	Moist or free draining soil, frost tender when young.
4	**kamahi**	*Weinmannia racemosa*	Moist soil, in open, likes moist banks.
5	**kapuka, broadleaf**	*Griselinia littoralis*	Moist soil, in the open or in shade.
6	**northern rata**	*Metrosideros robusta*	Moist to dry raised sites, in open but frost tender.
7	**houhere, lacebark***	*Hoheria sexstylosa*	Moist to dry soil, in the open.
8	**tarata, lemonwood***	*Pittosporum eugenioides*	Moist to dry soil, in the open.
9	**manatu, lowland ribbonwood***	*Plagianthus regius*	Moist to seasonally wet soil, in the open.
10	**kohuhu, black matipo***	*Pittosporum tenuifolium*	Wet or dry soil, in the open or in shade.
11	**totara**	*Podocarpus totara*	Moist or free draining soil, in semi-shade.
12	**swamp maire, maire tawake**	*Syzygium maire*	Moist or seasonally wet soil, in the open or in semi-shade.
13	**pokaka**	*Elaeocarpus hookerianus*	Moist or seasonally wet soil, in the open or in semi-shade.
14	**rimu**	*Dacrydium cupressinum*	Moist soil, in semi-shade or the open.
15	**hinau**	*Elaeocarpus dentatus*	Moist soil, in semi-shade or the open.
16	**black maire**	*Nestegis cunninghamii*	Moist to dry soil, in semi-shade to open.
17	**white maire**	*Nestegis lanceolata*	Moist to dry soil, in semi-shade to open.
51	miro	*Prumnopitys ferruginea*	Moist soil, in semi-shade.
52	matai	*Prumnopitys taxifolia*	Moist soil, in semi-shade.
53	kahikatea	*Dacrycarpus dacrydioides*	Moist to seasonally wet soil, in semi-shade.
54	pukatea	*Laurelia novae-zelandiae*	Moist to wet soil, in semi-shade, frost tender.
55	titoki	*Alectryon excelsum*	Moist or free draining soil, in shade (requires protection from frost).
56	mahoe	*Melicytus ramiflorus*	Moist or free draining soil, in shade to semi-shade (requires protection from frost).
57	tawa	*Beilschmiedia tawa*	Moist or free draining soil, in the shade (requires protection from frost).

Bold indicates early successional, pioneering species;

Asterisk (*) indicates pioneering species that can be planted in large numbers because of their rapid establishment and tolerance to most environmental conditions.

‡ see Figures 148-150

Table continued on page 116

Figure 149: Typical stream profile.

This stream profile shows a gentle bank on the left and a moderately steep bank on the right, with spring-fed low flows. The scale is exaggerated.

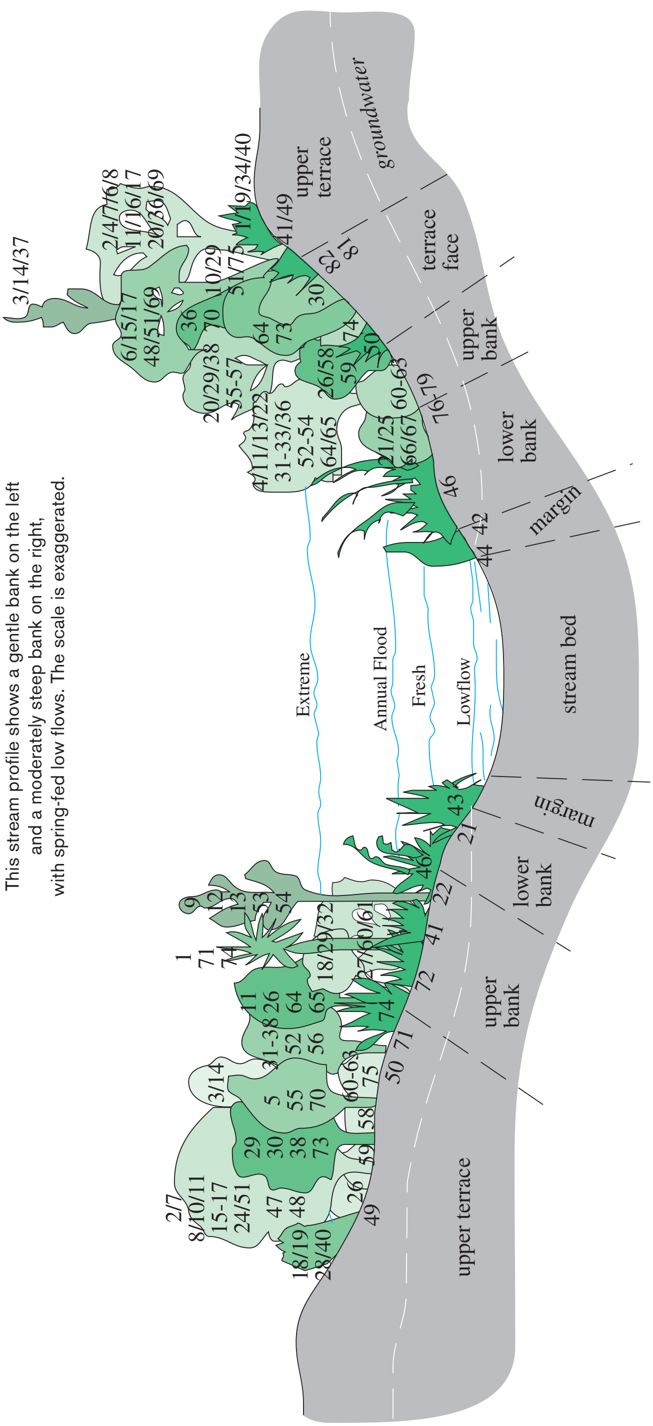


Table 8: Planting guide for native plants common in central New Zealand (continued)

Subcanopy trees and shrubs			
Key‡	*Common names*	*Species name*	*Conditions – where to plant*
18	**manuka, tea tree***	*Leptospermum scoparium*	Dry to wet soil, in the open.
19	**soft and prickly mingimingi***	*Cyathodes fasciculata, C. junipera*	Free draining or dry rocky soil, in the open.
20	**kowhai***	*Sophora microphylla*	Free draining soil, in the open (nitrogen fixing).
21	**tutu**	*Coriaria arborea*	Moist soil, in the open (nitrogen fixing).
22	**koromiko***	*Hebe salicifolia*	Moist soil, in the open.
23	**ngaio**	*Myoporum laetum*	Moist to dry soil, in the open, somewhat frost tender
24	**narrow-leaved lacebark***	*Hoheria angustifolia*	Moist to dry soil, in the open.
25	**weeping mapou**	*Myrsine divaricata*	Moist to seasonally wet soil, in the open.
26	**karamu***	*Coprosma robusta*	Wet or dry soil, in the open or in shade.
27	**mingimingi***	*Coprosma propinqua*	Wet or dry soil, in the open.
28	**akeake**	*Dodonaea viscosa*	Dry soil, open - semi-shade
29	**fivefinger, whauwhaupaku**	*Pseudopanax arboreus, P anomalus*	Free draining deep soil, in semi-shade to open.
30	**karamu (shining)**	*Coprosma lucida*	Free draining soil, in open or semi-shade.
31	**putaputaweta, marbleleaf**	*Carpodetus serratus*	Moist free draining soil, in semi-shade to open.
32	**kotukutuku, tree fuchsia**	*Fuchsia excorticata*	Moist or free draining soil, in semi-shade to open (requires protection from frost).
33	**makomako, wineberry**	*Aristotelia serrata*	Moist or free draining soil, in semi-shade to open (requires protection from frost).
34	**heketara**	*Olearia rani*	Moist to dry soil, in semi-shade to open.
35	**coastal tree daisy**	*Olearia solandri*	Moist to dry soil, in semi-shade to open.
36	**rohutu, NZ myrtle**	*Lophomyrtus obcordata*	Moist to free draining soil, in the open or in semi-shade.
37	**lancewood, horoeka**	*Pseudopanax crassifolius*	Moist to free draining soil, open to semi-shade.
38	**mapou**	*Myrsine australis*	Moist to free draining soil, in semi-shade to open. (requires protection from frost).
39	**swamp (twiggy) tree daisy**	*Olearia virgata*	Moist or wet soil, in semi-shade to open.
40	**rangiora**	*Brachyglottis repanda*	Moist or free draining soil, in semi-shade to open.

Bold indicates early successional, pioneering species;

Asterisk (*) indicates pioneering species that can be planted in large numbers because of their rapid establishment and tolerance to most environmental conditions.

‡ see Figures 148-150

Table 8: Planting guide for native plants common in central New Zealand (continued)			
Subcanopy trees and shrubs (continued)			
Key‡	*Common names*	*Species name*	*Conditions – where to plant*
58	kanono	*Coprosma grandifolia*	Moist or free draining soil, in semi-shade.
59	hangehange	*Geniostoma rupestre*	Moist or free draining soil, in semi-shade.
60	small leaved coprosma	*Coprosma rhamnoides, C areolata*	Moist soil, in semi-shade
61	round-leaved coprosma	*Coprosma rotundifolia*	Moist soil, in semi-shade.
62	poataniwha	*Melicope simplex*	Moist soil, in semi-shade.
63	pate, 7 finger	*Schefflera digitata*	Moist soil, in semi-shade.
64	turepo, milk tree	*Streblus heterophyllus*	Moist to seasonally wet soil, in semi-shade (requires protection from frost).
65	kaikomako	*Pennantia corymbosa*	Moist to seasonally wet soil, in semi-shade.
66	swamp mahoe	*Melicytus micranthus*	Moist to wet soil, in semi-shade to shade.
67	swamp coprosma	*Coprosma tenuicaulis*	Moist to wet soil, in semi-shade.
68	perching kohukohu	*Pittosporum cornifolium*	Plant as an epiphyte in semi shade.
69	perching lilies	*Astelia solandri, Collospermum hastatum, C. microspermum*	Plant as an epiphyte in semi shade.
70	myrtle	*Neomytus pendunculata*	Moist or free draining soil, in semi-shade to shade.
71	silver fern	*Cyathea dealbata*	Moist soil, in shade (protect from frost).
72	wheki, hard treefern	*Dicksonia squarrosa*	Moist soil, in shade (requires protection from frost).
73	pigeonwood	*Hedycarya arborea*	Moist soil, in the shade (requires protection from frost).
74	nikau	*Rhopalostylis sapida*	Moist to seasonally wet soil, in shade
75	horopito, peppertree	*Pseudowintera colorata*	Moist to seasonally wet soil, in shade.
Groundcover and climbers			
41	**toetoe grass, toitoi**	*Cortaderia toetoe, C. fulvida*	Moist soil, in the open.
42	**umbrella sedge, upoko-tangata**	*Cyperus ustulatus*	Moist to dry soil, in the open.
43	**tussock rushes**	*Juncus pallidus*	Moist to wet soil, in the open.
44	**spike-sedge**	*Eleocharis acuta*	Semi-aquatic conditions, in the open.
45	**pukio, tussock sedge, makura**	*Carex secta, Carex virgata*	Wet soil, in the open.
46	**harakeke, NZ flax***	*Phormium tenax*	Wet to moist soil, in the open.

Bold indicates early successional, pioneering species;

Asterisk (*) indicates pioneering species that can be planted in large numbers because of their rapid establishment and tolerance to most environmental conditions.

‡ see Figures 148-150

Table 8: Planting guide for native plants common in central New Zealand (continued)			
Groundcover and climbers continued			
Key‡	*Common names*	*Species name*	*Conditions – where to plant*
47	**climbing broadleaf, puka**	*Griselinia lucida*	At base of young tree in the open or semi-shade
48	**climbing ratas**	*Metrosideros fulgens, M. colensoi, M diffusa, M perforata, M carminea*	At base of young tree in the open or semi shade
49	**kakaha, bush lily**	*Astelia fragrans*	Moist soil, in semi-shade to open.
50	**turutu, NZ blueberry**	*Dianella nigra*	Moist soil, in semi-shade to open.
76	rough pigfern	*Hypolepis ambigua*	Moist soil, in shade.
77	kiokio	*Blechnum chambersii, B. fluviatile*	Moist soil, in shade.
78	mata, water-fern	*Histiopteris incisa*	Moist soil, in shade.
79	hounds tongue fern	*Phymatosorus pustulatus*	Moist soil, in shade.
80	puniu, prickly shield fern	*Polystichum vestitum*	Moist soil, in shade.
81	NZ iris, mikoikoi	*Libertia ixioides*	Moist to dry or free draining soil, in shade.
82	pikopiko	*Polystichum richardii*	Moist to well drained soil, in shade.

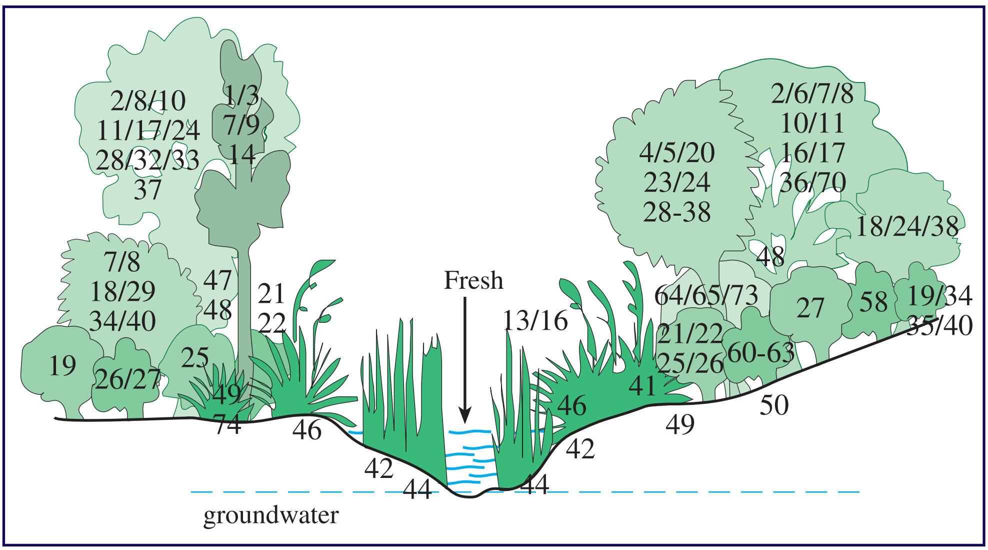
Bold indicates early successional, pioneering species;

Asterisk (*) indicates pioneering species that can be planted in large numbers because of their rapid establishment and tolerance to most environmental conditions.

‡ see Figures 148-150

Figure 150: Seasonal stream profile.

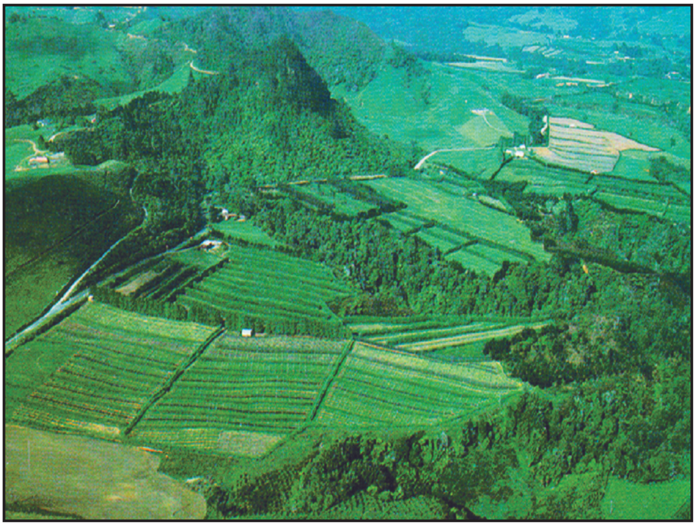
This profile shows upper stream reaches with seasonal water flows in winter or after heavy rain (called a 'fresh'). The scale is exaggerated.



PART 2: INTEGRATED MANAGEMENT STRATEGIES

Resilient landscapes

…bush protection and farm production
integrated and sustainable



Please visit www.bushvitality.org.nz
and www.landcare.org.nz to:

- View related projects and relevant contacts
- Exchange information about Bush Vitality Assessment/Restoration and Native Afforestation projects in other parts of the country.
- Grow Common Futures.

Agroforestry

The production land next to river or stream corridors is often grassed or growing other single crops.

Agroforestry is a collective term used to describe a wide range of sustainable land-use practices, which have a long tradition in Europe (grazed woodland[15], standard fruit tree meadows[16], parkland, dehesa[17]) and other parts of the world. As new technologies and innovative practices are applied[18], outstanding production levels are achieved. It integrates well with ecosystem processes, achieving biodiversity benefits and landscape character with high recreational and amenity value. Species combinations necessarily differ depending on local environmental conditions and the anticipated productive outcomes. It is a sustainable production method with exceptional economic benefits.

Figure 151: Agroforestry examples: Compatible trees on pasture (oak, elm, hickory and ash). Inset: walnut and pear tree cropping. HJ

Agroforestry uses extra spatial dimensions for production. Agroforestry designs incorporate a succession of compatible trees and shrubs with annual or perennial crops or forage, growing in 2 or 3 storeys.

Agroforestry typically establishes tap-rooting nut trees (for example walnut, chestnut, pecan) or standard fruit trees (pear, cherry, apricot, almond, olive) along with annual or perennial crops or short-lived fruit trees (peach, sour-cherry, bush-apple, plum).

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15 Woodland: Grazed and foraged woodlands usually contain ash, oak, elm, chestnut, beech, *Sorbus spp* and *Prunus avium*.

16 Standard fruit tree meadows: popular German agro-ecosystem of (half-) standard (120-180cm tree trunks). Fruit trees include 1400 apple varieties and 1500 varieties of plum, pear, cherry, *Prunus cerasus*, walnut. They are grown at 20 to over 100 trees/ha, on private land and commons (road margins), inter-cropped for human consumption and producing forage for stock, poultry and pigs.

17 Dehesa: Iberian silvo-arable system with scattered mast oaks (20-50 trees/ha) intercropped with cereals or fodder crops followed by 5-10 years of perennial pasture. Olives or carob (*Cerotonia siliqua*) are grown as silvo-arable systems, intercropped with cereals or vineyards throughout the Mediterranean.

18 Row-planting of compatible tree species for mechanized cultivation.

Herbaceous intercrops (legumes, vegetables, herbs) effectively prevent weed growth during the early establishment phase.

Plant species that produce early or late in the year, or that grow well under semi-shade are more suitable for intercropping later on, and may include:

- Annuals such as radishes, legumes, squash, spinach, beetroot, borage, basil, garlic, leeks, winter-lettuce, cereals (durum wheat, barley, rye, soybean, canola (*Brassica napus*), sunflowers, alfalfa, buckwheat
- Perennial herbs, vegetables or bulbs such as rhubarb, chives, strawberry, comfrey, nasturtium, rue, ginseng, flowers
- Fruit-bearing shrubs such as black and red currants, gooseberry.

This agroforestry-crop system can be maintained, followed by, or alternated with a silvopastoral system, (*Lolium perenne*; *Cynosurus cristatus*; *Poa trivialis*; *Trifolium repens*; chicory) where stock grazes and forages under long-lived standard fruit and nut trees.

In North America black walnuts or pecans are commonly planted at 270 trees per hectare. A row spacing of 12.5m and tree spacing of 3m provides sufficient surplus trees from which the best trees can be selected to a final stocking of 75 walnut trees per hectare within 25 years.

Agroforestry production has stimulated strong scientific and growing political interest over the past few decades. Case studies on tree crop production around the world's temperate zone (Europe, North America, China, South Africa, Chile and Argentina and Australia) consistently demonstrate higher production of agroforestry systems over single crop systems.

1. Europe:
   Radish intercropping with pear trees achieves 60% higher economic and over 100% higher biomass yields over single species cropping. Over a period of 60 years an agroforest has a 20% higher yield compared with a forest plantation.
2. North America:
   Economics of 'eastern black walnut alley cropping' were assessed in the state of Missouri (USA). The internal rate of return (IRR) ranged from 5.5% when trees are grown in forage regimes to as high as 11% in more complex regimes, which include wheat, soybean and hay. Nut production added another 0.5 to 2.2% to the IRR.
3. China and Europe:
   Where land is scarce, an agroforest of peach trees and vegetables is a high-profit option. This irrigated system is very efficient, as no water competition occurs and also because winter and spring vegetable growth benefits from full sunshine until mid-spring.

Agroforestry also has far fewer insect pest problems than conventional production methods. Insect predators are generalists that benefit from an agroforestry environment and effectively control crop-host-specific insect pests.[19]

Productivity of agroforestry is higher compared to monocultures and can reduce the need for fertilisers and pesticides, which adds up to higher financial returns and better sustainability. (Compare Appendix 'Further reading' Agroforestry references.)

AGROFORESTRY'S EMERGENCE IN NEW ZEALAND

Silvopastoral agroforestry was first considered in New Zealand in 1969, using *Pinus radiata.* Pine's pruning and thinning off-cuts, however, do not contribute much to the pastoral regime. The removal of thinning and pruning debris is a practical limitation, as are pines' effects on grass growth and soil quality. The continued profitability of this particular combination is doubtful for many parts of New Zealand.

Several research institutes have focused for some time on the breeding of, and applications for poplar hybrids, which are more compatible with a grazing regime. They have been widely planted with incentives from regional government for erosion control purposes.

While there is very little research on compatible species and particularly species synergies in New Zealand, there is considerable interest and experience. Members of the NZ Tree Crops and Permaculture Associations and organic farming organizations have for some decades gathered valuable experience with compatible species combinations for agroforestry.

Agroforestry is a very suitable land use in New Zealand's lowland and rolling hill country, and particularly appropriate for areas adjacent to fenced and regenerating native river or stream corridors. Both bush and rural vitality can be strengthened by innovative and sustainable agroforestry, which can be adapted to local environmental conditions and generate new economic opportunities.

Afforestation appetizers

Many trees produce edible nuts from year 10 to 20, as well as valuable timber. Where native afforestation is the long-term goal, tree nuts can be planted at favourable sites to provide valuable yields before trees can be harvested for their timber.

Smaller trees (almonds, hazelnuts) can be planted at 250-600 trees per hectare, producing 4-5kg/tree of nuts within 10 years and up to 15kg/tree or 1,5 t/ha.

Larger trees (chestnut, walnut, pecan, macadamia, white oaks (see table 11, p.131)) can be planted at 30-100 trees/ha, producing 45kg nuts/tree or 4 t/ha by year 10 and up to 180kg nuts/tree or 6-12 t/ha. Wholesale returns for unshelled nuts range between NZ$2-5/kg. Shelled nuts retail at NZ$15-40/kg (see Table 12, page 135).

19 Insecticide use against aphids on wheat is no longer necessary in Bavaria (Germany) because of an increasingly restored agroforestry system that enhances the landscape's capacity for natural pest control.

Steep-land afforestation

"If you cannot cut hay off it – plant trees" (Wise 2001).

Many sheep and cattle farmers throughout the country are already planting multi-purpose farm forestry lots for stock shelter and on marginal grazing land.

Figure 152: Steep-land agroforestry with spaced poplars.
Inset Tree lucerne *(Chamaecytisus palmensis).* HJ

Pioneering farm foresters have gained valuable experience with more efficient uses for marginal grazing land than the burn-offs of years gone by. One farm forester tells of doubling his 230-hectare farm's capital value with his 100-hectare multi-purpose plantation and doubling the farm's net income by harvesting 3 hectares annually.

Much of the North Island's hill country is highly erodible and steep. Steep-land afforestation policies and projects have been implemented for several decades to establish sustainable land uses on erosion-prone land. Suitable tree species need to have both high tensile root strength and low rates of root decay following tree harvest, for erosion to be effectively reduced.

Roots of fast growing softwoods (conifers) tend to have less tensile strength and decay more quickly than similar-sized roots from hardwood trees (compare Table 9, page 125). Slope stabilization generally occurs about 6 years after tree (root) establishment. A mature root network needs to be maintained at all times on erosion-prone sites to achieve any erosion policy's purpose.

Pines and poplars have for some time been planted for this purpose. They readily establish and rapidly produce a versatile wood. Poplars are commonly used for agroforestry and are particularly useful where their removal of excess soil moisture stabilizes slumps. Pines have more commonly been planted on land regarded too steep for grazing.

Pines however deplete vital topsoil nutrient reserves. Pine litter accumulates acidic mor-humus of which derivatives leach into the soil, effectively enabling pines to raid the soil's mineral nutrient stores. Pines assimilate nitrogenous compounds by decomposing Mull/Moder humus types deposited by previous nutrient-cycling plant associations, thereby reducing a soil's organic nutrient and water storage capacity. Eucalypts, having adapted to infertile Australian soils, have the same effects as pines when planted on more fertile NZ soils. Both pines and eucalypts raid a soil's capital or capacity to sustain other tree crops. Their fast growth comes at a price and their rotations' sustainability is questionable on many New Zealand soils, where existing pine and eucalypt plantations should not be clearfelled and 'rotated'. Rather such plantations could be replaced using shelterwood harvesting methods (see page 163) by interplanting with compatible or native trees in lanes or blocks and managed as permanent forests thereafter (compare Reafforestation models, page 126-138; Tables 12 to 14, pages 135-146).

Soil erodes with each clearfelling and for at least another 5 years thereafter, until newly planted tree roots re-stabilize slopes and topsoil regenerates over the following decades. Table 9 (page 125) shows that many hardwood tree species out-perform pines and other exotic softwoods in achieving hill slope stability, while generating organic nutrient and water storage capacity in topsoil.

Steep hill country needs permanent forest cover to effectively halt soil erosion and biodiversity decline. There is much scope to integrate environmental needs and permanent productivity, as natural succession is given direction, applying shelterwood forest harvesting techniques and inter-planting a succession of valuable compatible and native tree species (see Table 12 - Table 14, pages 135-146).

Tree suitability for erosion control

Table 9: Comparison of tree performance in reducing hill erosion					
Trees	**Growth rate** Height after 20 years. (Pardy, 1992; Halloy, 1996; FRI, 1989)	**Strength: Life root-strength** Mean tensile strength (Phillips and Watson, 1994); ***(Strength of dry timber)*** (Clifton, 1990)	**Elasticity: Shear strength** Measure of a beam's stiffness Modulus of Elasticity at 12% moisture content; (Clifton, 1990)	**Root decay:** Time by which ½ root strength is lost (Phillips and Watson, 1994)	**Durability:** Untreated heartwood in the ground. (Phillips and Watson, 1994; FRI, 1982)
Exotic conifer softwoods	**Metres**	**Megapascal**	**Gigapascal**	**Months**	**Years**
Pinus radiata	18	17	9	15	5
Douglas fir *Pseudotsuga menziesii*	12	27 *(78)*	9	5–10	
Macrocarpa *Cupressus macrocarpa*	10	*(74)*	8	10– 5	
Exotic hardwoods					
Alder *Alnus rubra A. acuminata*	20	32-52	5 – 10		
Blackwood *Acacia melanoxylon*	12	*(130)*	14	Up to 25	
European ash *Fraxinus excelsior*	15	*(116)*	12	5–10	
White oaks	12	32-50 *(180)*	20	Up to 25	
Poplar *Populus deltoides; P. euramericana*	22	37-46 *(62)*	7	5–10	
Robinia *Robinia pseudoacacia*	15	70 *(115)*	10	Over 25	
Native conifers	**Metres**	**Megapascal**	**Gigapascal**	**Months**	**Years**
Rimu *Dacrydium cupressinum*	9	(88)	10	10–15	
Totara *Podocarpus totara*	8	(62)	7	Over 25	
Miro *Prumnopitys ferruginea*	5	(94)	10	5–10	
Native hardwoods	**Metres**	**Megapascal**	**Gigapascal**	**Months**	**Years**
Black maire *Nestegis cunninghamii*	6	*(114)*	12	Up to 25	
Kanuka *Kunzea ericoides*	12	33 *(127)*	13	39	5–10
Kowhai *Sophora spp*	10	*(135)*	14	Up to 25	
Manuka *Leptospermum scoparium*	6	34	5 – 10		
Puriri *Vitex lucens*	13	Over 25			
Rata *Metrosideros robusta; M. umbellata*	8	51 *(114–183)*	12-21	49	Up to 25
Beech *Nothofagus spp*	12	33 *(113–116)*	12-14	33	Up to 25
Rewarewa *Knightia excelsa*	10	*(125)*	18	5–10	
Tawa *Beilschmiedia tawa*	8	*(114)*	13	5	

Reafforestation models

The New Zealand Forest Research Institute (Scion), Tane Tree Trust, the Native Forest Restoration Trust and QEII National Trust have for some time been involved in native plantings to enhance native forest remnant resilience and out of concern for the continued sustainability of native timber resources (see Figure 146, page 105).

Scion's main reseach focus is on exotic conifers, particularly *Pinus radiata*. The growth rates of native trees are being monitored at a number of sites. Management options for native species are being researched with a particular focus on totara in regenerating and planted stands. Amongst the hardwoods, rewarewa and puriri have shown growth rates in new plantings comparable to some of the best exotic hardwoods. Planting native trees may be:

1. necessary where original seed-trees were removed, or
2. desirable because:
   - remaining trees in the forest remnant are of inferior quality where the best specimens were felled
   - planting native seedlings could speed up their natural regeneration by 10-50 years
   - infilling long forest-edge perimeters reduces pest infestation potential thus generating economic and ecological benefits.

If good local parent trees and provenances (site adapted, high quality, old lineage trees) cannot be sourced, it is often best to plant compatible exotic trees and hope that existing native juveniles will turn into high quality future parent trees. Their seed can be propagated in future, or regeneration can be left to natural succession under compatible exotic trees.

In several studies (see Appendix, Further Information, Native Bush Management), planted native trees had their growth monitored in gaps of small native and exotic forest clearings, in lanes of regenerating scrub forest and on open grassland. Results indicate that native seedlings should be 50-80cm tall when planted and released for 5 years until 2m tall. Native seedlings benefit from side shelter and a clearing above. They do well planted in forest or scrub among natives or compatible species while planting under pine or eucalypt forest or in grass is less successful. Other results included:

1. Planting in forest or scrub gaps is best done on good micro-sites (4-6m diameter) in groups of 3-5 seedlings. If the gap centres are at 15m intervals the stocking rate will be 180-300 stems per hectare.
2. Lanes may be cut into exotic scrub, generally less than 3m wide depending on scrub height and slope. Puriri, rewarewa and titoki were planted in lanes 8m apart with a seedling spacing of 3m and a stocking of 400 stems per hectare.

3. On open sites, the lack of shelter and competition from grasses limited tree establishment. Plantings benefit from a nurse crop, planted at least 3 years in advance at stockings of 800-2500 stems per hectare. Compared with the other native conifers totara competes best with grasses. Hexagonal or triangular planting patterns use space better than rectangular ones.

Suitable nurse crops include kohuhu, wineberry, karamu, broadleaf, narrow-leaved mahoe, koromiko, tree lucerne. Manuka and kanuka also provide some protection from browsers. Other suitable native pioneering trees are highlighted in **bold print** in Table 8 (pages 114-8).

Reforestation on open land

Farm foresters can raise top quality tree crops efficiently, using wild seedlings with one of two reforestation models (Compare Table 10, page 129 and Table 11, page 131). Both models can be applied on pasture or fields of any slope and may be used to establish linkages between forests or plant up native forest perimeters to achieve compact and resilient bush shapes. The models utilize natural selection and succession processes to the forester's advantage. All seedlings are planted at the same time with herbaceous plants as companions (buckwheat, legumes, rye) or on cultivated micro-sites.

Best timber qualities and rapid environmental benefits are achieved by:

- planting seedlings of the same species next to each other within small blocks or lines (well-shaped, vigorous trees are selected for final tree crop)
- companion planting (this achieves best use of resources and space over time).

Companion planting associates in alternating lines or blocks:

- tap-rooting with shallow-rooting trees;
- fast-growing and light-requiring with more shade-tolerant trees or
- slower growing trainer trees with trees of medium growth habit and light requirements.

Seedlings should ideally be sourced from good parent trees, which originate from environments that match the environmental conditions of your planting site. Nurseries often collect tree seeds for propagation from accessible trees with desirable attributes. Repeated collection from the same parent tree can restrict the genetic diversity and affect the vigour of a valued tree species. Seedling vigour may also be affected by:

- chance pollination in the wild or
- a tree population's adaptations that may not suit the environmental condition of the planting site.

Good silviculture can successfully address these issues.

Silvicultured stands from wild seedlings eventually contain superior seed-producing trees that adapt to a site's environmental conditions. Shelterwood harvesting techniques are carefully applied following mast-seeding years with good establishment of seedlings to repeat the sustainable forestry cycle.

The following two reforestation models can be used to establish a permanent multi-purpose forest of highly valued natural timber species directly on open ground and from wild seed stock.

Natural selection model (Table 10, page 129)

Past clearance and selective logging often removed the best parent trees, leaving trees with less desirable timber properties. Compatible exotic trees often originate from limited seed stock. Silviculture can effectively reinvigorate tree populations and improve native and compatible trees' timber value without a need for elaborate breeding and cloning programmes, often resulting in erosion of a species' genetic diversity. About 10-15 percent of timber-tree seedlings express genotypes that have the potential to achieve desirable growth form and finest timber qualities. The purpose of the selection model's design is to minimise establishment costs and:

- Ensure optimal establishment of target-trees for a given area (>100 top quality trees/ha with branch-free boles of at least 6-8 m)
- Achieve better seed stock for future tree generations by applying natural selection processes that enhance rapid growth of vigorous saplings.

This model can rapidly improve the future productivity of a target tree species and requires just 1,900 to 2,700 tree seedlings per hectare plus 1200-1600 trainer trees/ ha. Each circle contains the same species. Neighbouring circles may of course contain different tree species, as a particular design may be required to:

- Facilitate a progressive harvest of different wood products from small coupes
- Make best use of variable environmental site conditions (soil, aspect, exposure, frost hollow).

The silviculture that follows plant establishment under this model is concerned with tending the best young trees. Less vigorous saplings are removed over the first decade and trees from the outer circle and between circles may progressively be harvested thereafter.

Inner circle (● symbols) native and compatible exotic trees with good economic prospects that would benefit from 'silvicultured' natural selection may include **puriri, black maire, hinau, rata, pokaka, kohekohe, titoki, native beeches, podocarps or white oaks, ashes, hickory (pecan).**

Outer circle (○ symbols) native and compatible trainer trees may include: **Kanuka, kohuhu, kowhai, totara, putaputaweta, alders, rowan, birch, linden, robinia**. In remote locations the outer circles may be planted with unpalatable, pioneering shrubs and small trees with complementary features[20] to the tree species of the inner circle: **koromiko; tutu; lemonwood; coprosma; lancewood; rangiora; mapou; ngaio; horopito; kaikomako; pigeonwood**.

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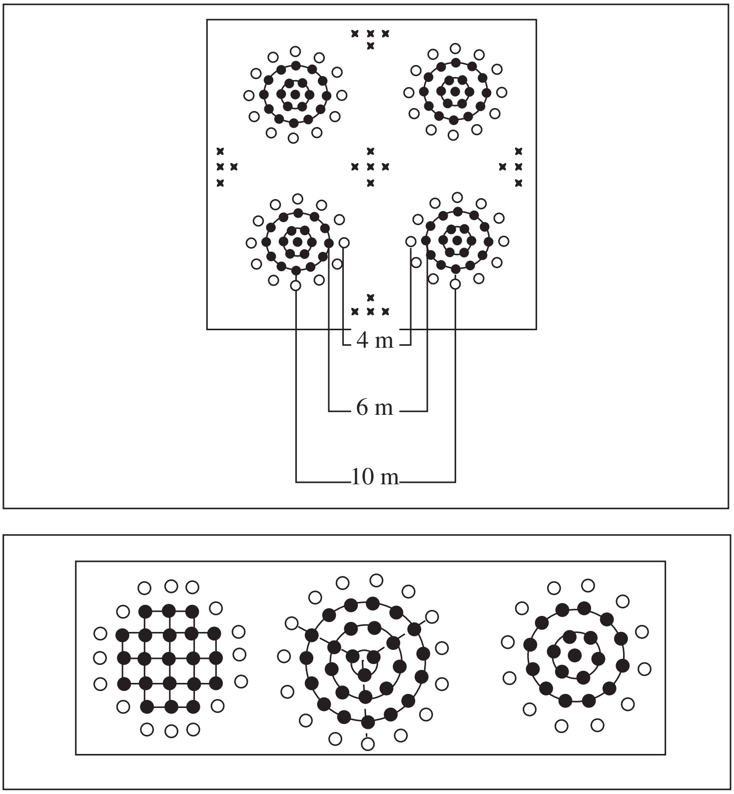
20 Complementary features may include nitrogen fixation, different growth rate and form, light requirements and root shapes.

Table 10: Natural selection afforestation model.
Selects quality trees from wild seedlings (for timber; future seed source; site adaptation)



The spaces between the circles (✕ symbols) may be planted with either:

- Fast growing complementary pioneering species that help train the final tree crop and provide interim financial returns (**kanuka; kowhai; pittosporum; red, Andean, grey alders; poplars; mulberry; acacias; robinias**)
- Valued mid succession broadleaf trees (see Table 12, pages 135-138) such as **ashes; elms; wild cherry; maples; chestnut; hickory (pecan); white oaks; black walnuts; native puriri and beech canopy trees**. Slightly slower growing trees (linden and many native broadleaves) that are planted in the inner circle can push these trees to perfect harvestable shape within 40-80 years.
- Trees that are generally left alone by browsers such as **totara; rewarewa; kahikatea; pukatea; the beeches; hinau; rimu; nikau; matai; miro**.
- Late succession native podocarp trees. These push mid succession broadleaves' selection process to achieve top quality timber and parent seed-trees for future forests.

Natural succession model (Table 11, page 131)

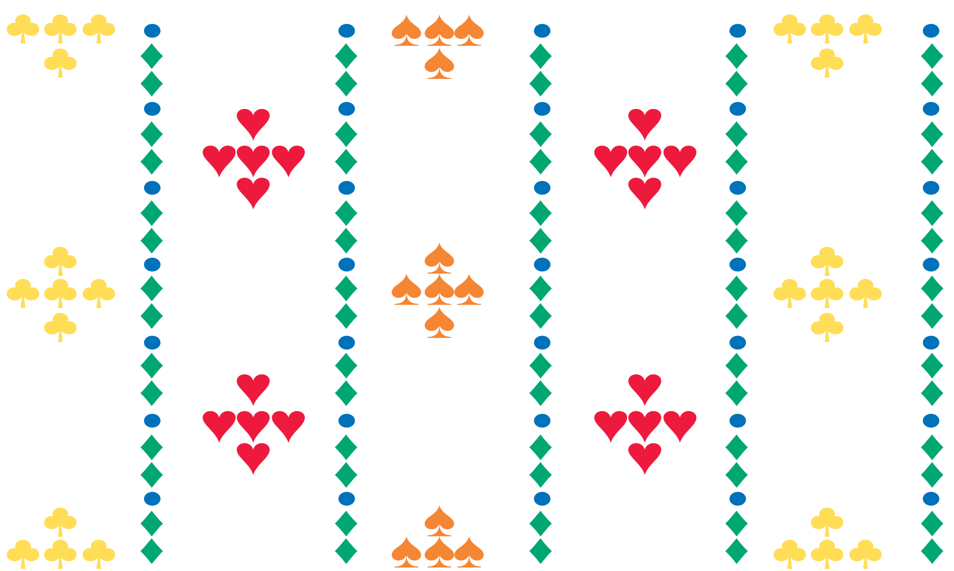
The afforestation silviculture ecologist can achieve desired forest qualities by combining tree species that pull (1) and others that push (2) up to four valued target canopy tree generations to desirable shape over 70-90 years.

1) Fast growing pioneer tree species (such as alders, robinia, poplars) and second generation pioneers (black walnut, elm, bird cherry etc) pull mid and late succession trees. The best seedlings grow to trees, which can be easily extracted along rows, providing interim financial returns (15-50 years after establishment). The mid and late succession trees are thinned, using shelterwood timber-extraction techniques, leaving the best trees and optimising the site's capital value.
2) Valued fast mid-succession trees (such as light requiring oaks, walnut, chestnut) are pushed to good shape by slightly slower growing shade-tolerant native timber trees. Podocarp trees usefully push the 4^{th} native canopy generation and female podocarp trees remain to pull future canopy generations (compare Table 12 pages 135-138) Small coupes/strips (under 1 ha) are best felled over winter and following a mast-seeding year to reinitiate a natural succession cycle in the forest gaps. Additional site-specific plantings provide resilience to the regenerating forest gap and reliable sustainable production.

When applying a tree planting model and selecting a range of suitable species, the afforestation silviculture ecologist takes into account a tree species' ecology and origin, its uses and values, its response to local environmental conditions and designs a specific sequence of shelterwood harvesting operations that maximise the sustainable rate of return for each managed forest ecosystem.

The possibilities for successful tree species combinations using both planting models are virtually unlimited, where the forester's and landowner's knowledge, experience and vision combine to invent and establish robust land use techniques. (Compare Tables 12 (page 135-137); 13 and 14 (pages 140-146); Figure 156 (page 138)).

Table 11: Natural succession afforestation model.
Cost-effective perpetual silviculture, yielding 5 successive harvests of canopy trees within 100 years.



♥ = Fast pioneer trees. Up to 5 trees every 10x10m. Yielding from 15-30 years
♠ = 2nd pioneer trees. 5 every 10x20m offset. Yielding from 30 years
♣ = Fast mid succession trees. 5 every 10x20m offset. Yielding from 50 years
♦ = Mid succession 5x1m. 4th generation yields from 75 years
● = Native late succession tree 5x3m (every 3rd tree). Yielding from 100 years
2200-3000 tree seedlings per hectare (Establishment costs: NZ $3-4,000)[21]

Examples:
♥ = Shipmast-robinia; poplar; alder (*A. acuminata*); acacias; birch; lacebark; ribbonwood. Small trees: Akeake; kanuka; kotukutuku; pittosporum; hazel (10x2m).
♠ = Red alder; bird cherry (*Prunus avium*); elm (*Ulmus glabra*); tasmanian blackwood; black walnut; red oaks[22]; mulberry; rowan; kowhai.
♣ = White oaks[23]; chestnut; ash spp; elm (*U. procera*); maples; walnut; hickory.
♦ = Red-, hard-, black-, silver beech; puriri; rata; rewarewa; totara; linden.
● = Black maire; hinau; kohekohe; mangeao; titoki; tawa; kahikatea; matai; miro; rimu.

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21 This estimate is based on an eco-sourced native river corridor restoration project, near Palmerston North. Growing on costs: ($2,000/2200 plants). Establishment costs ($1,000/hectare for planting, staking, mulching, releasing).

22 Red oaks grow fast, acorns are not generally stock palatable (*Quercus rubra; Q. coccinea; Q. palustris; Q. cerris; Q. ilex*).

23 White oak timber is generally more valuable than red oak timber and acorns are stock palatable (*Quercus petraea; Q. robur;* American oaks: *Q alba; Q michauxii; Q. muehlenbergii; Q macrocarpa; Q. lobata; Q. gambelii; Q. prinus;* and Mediterranean oak varieties, selected for stock palatability *Q. ilex var rotundifolia; Q. suber; Q. faginea*).

Planting fire-wise

When you plant your forest adjacent to incompatible, fire-supporting pine or eucalypt forests, also plant a buffer zone of fire-retarding native plants to safeguard your native/compatible tree plantation. Cleared firebreaks are important for access but are often rapidly covered by secondary fire-supporting vegetation like gorse, broom, pampas grass or manuka.

The effective buffer zone width depends on the fuel-load, which depends on the pine/eucalypt plantation's age, its size and the depth of its flammable litter layer. Fire retarding buffer zones need to be wider up-slope and down-wind of a pine or eucalypt forest compared to down-slope and up-wind, where the width should be about twice the final tree height (40-100m).

Figure 153: Tutu (*Coriaria arborea*). J Janssen

Tutu is an effective first line of defence, followed by plants that have been shown to survive low intensity fires: NZ flax; cabbage tree; *Coprosma;* tree ferns*; Dicksonia spp; Hebe salicifolia;* mahoe, broadleaf, whiteywood*;* wineberry*;* tree kotukutuku.

Figure 154: Karamu ♀ (*Coprosma robusta*). J Janssen

Figure 155: Tree fuchsia (*Fuchsia excorticata*). J. Janssen

Projected sustainable yields

For many, planting native trees is an admirable altruistic achievement that maintains native biodiversity and protects Papatuanuku. Others may consider planting native forests to finance their children's retirement. On retirement, their children may appreciate their elders' foresight and reciprocate their generosity.

Prospective native foresters do not need to rely solely on such worthy and noble deeds, since sustainable yields are obtainable surprisingly fast with the support from an afforestation silviculture ecologist.

A planted forest's productivity and potential yield increases exponentially for approximately one century, eventually reaching a site's permanent productive potential. Silviculture ecologists can increase opportunities and yields, and enhance a planted forest's productivity, by integrating compatible exotics and purposefully managing the succession cycles of indigenous forests.

Afforestation silviculture ecologists elsewhere utilise a planted forest's exponential growth phase and achieve a consistent income from year 15 by thinning and managing the forest edge for yields of palatable tree-seeds or by:

- Pollarding or coppicing chestnut, robinia, blackwood, hazelnut, alder, elm, ash or hickory at 9-year intervals in order to yield sought after poles, posts, stakes, tool-handles, firewood.
- Inoculating plantings and thinned off-cuts with culinary specialities, such as Shitake mushroom (*Lentinus edoides*).

Three silvicultural harvesting systems (selection systems, shelterwood systems and clearcutting) emulate regeneration phases of distinct forest ecosystems.

A 'selection system' emulates the regeneration phase to which most native and compatible exotic tree species are best adapted. A 'shelterwood system' may be applied to regenerate pure beech forest or to convert exotic conifer or eucalypt plantations to indigenous forest. Clearcutting mimics stand regeneration following intense wildfires, to which New Zealand's forest ecosystems are not adapted. Totara and kahikatea often emerge as even-aged cohorts in gaps caused by flooding.

Our afforested multi-species, even-aged 'single-cohort stand' is best managed by a 'selection system' (an ecological silviculture programme of continuous cover forestry), which will convert it over time into an uneven-aged 'multiple-cohort stand' (Plenterwald), with all the beneficial attributes of a resilient indigenous forest ecosystem.

Ecological silviculture reaches optimum efficiency when a 'selection method' integrates silvicultural management, harvest and regeneration in a single operation. A silviculture ecologist may manage a planted stand by selection methods, such as:

- The **single-tree selection system** to manage one species' succession within a multiple species forest/plantation on 1/10th of a hectare. For example *puriri*, *maire*, *mangeao*, *beech* or *kohekohe* may each be managed on a 90 year rotation and a 15 year cutting cycle, where each age group occupies 1/60th of a hectare.

The single selection system potentially yields 90 m^3/ha/15-year cycle of top-quality merchantable puriri timber, returning $9-16,000/ha/yr at today's price. Yields include veneer timber (from 90yr puriri); veneer and saw-logs from puriri, thinned at year 75 and 60; timber for tools, cultural implements and crafts from puriri, thinned at years 45, 30 and 15.

- The **Group-selection system**. The final age-class consists of two or more single mature trees of one or more species. The regeneration openings can accommodate the ecological requirements of almost any tree species. It is practical and efficient if more light-demanding species are to be managed or re-introduced, such as *rewarewa, totara, rata, kowhai* and *beech*. It replicates the gap-phase regeneration of many late-successional temperate forest ecosystems.
- **The Strip-selection system** can facilitate log-extraction in difficult terrain. It can provide the required shelter to obtain advance reproduction of mid to late succession native timber species at rotations of 75-125 years. A strip as wide as one mature tree is harvested at 15-25 year intervals, advancing toward the equator (SSE=> NNW), creating 5 age-classes within a 60m-wide strip.

Best growth-rates are achieved where the diversity of a planted multi-species, multiple-cohort stand reflects a site's environmental gradients. An efficient sustainable yield from a mosaic of species and cohorts within a stand may require application of a range of selection and shelterwood systems within podocarp-broadleaf and beech stands over time.

Present wholesale timber prices for native and exotic hardwood timber range from NZ $1,200 – $3,000/$m^3$ (see Table 12 page 135-7). European markets pay up to three times as much for quality local hardwoods. Forty to 70 years after establishment, a stand of 60 to 150 top-quality canopy trees per hectare, is valued today at NZ $3-750,000/ha in New Zealand and over NZ $2,500,000/ha in Europe.[24]

Well-managed northern, multiple tree-species plantations consistently produce sustainable internal rates of return for forest owners (5-10% per year in Europe and North America). New Zealand's favourable tree-growing environment and use of compatible tree species can add value to a managed native forest succession, with the potential to exceed internal rates of return achieved elsewhere.

Table 12 shows silvicultural measures of planted and natural stands by decade and up to 200 years, often from trees growing in remnants of realised niches on sub-optimal sites. Harvestable tree species are colour coded to match an ecological afforestation model (see Table 11, page 131). Applying ecological afforestation silviculture on sites with optimal growth conditions within a species' fundamental niche can significantly increase yield per hectare.

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24 New Zealand timber prices are moving closer to overseas hardwood prices, as felling of trees from virgin native forests comes to an end and is replaced by certified timbers from planted forests, established and managed with the principles of ecological silviculture.

Table 12: Perpetual yields from ecological succession silviculture						
Yield in years after forest establishment	Tree yield continuity.[25] Data from: • Warm temperate NZ sites† • Cool temperate German sites§	DBH[26] Target (45->60cm)	Stocking (Stems/ha)	M.A.I.[27] (m^3/ha/yr)	Stand volume[28] (m^3/ha)	Timber price range(NZ \$/m^3)[29]
10	Hazelnut *Corylus avellana*† (Yield: 5kg/tree) (see page 122)	10	270-600			
Yields from thinning. Pollarding, coppicing at 15 year intervals.	Almonds *Prunus amygdalus* (Yield: 5kg/tree)	*10*	150-330			
	Macadamia *M. integrifolia*† (Yield: 30kg/tree)	10	400			
	Pecan *Carya illinoinensis* (Yield: 40kg/tree)	10-15	200			
	Walnuts *Juglans regia*† (Yield: 80kg/tree)	10-15	150			
	Chestnut *Castanea sativa*† (Yield: 50-100kg/tree)	10-15	250			
	White Oaks (see page 131)§ (Yield: 50-100kg/tree)	10-15	300			
	Tree Lucerne	10				
	Alder *Alnus* spp.	15-20				
	Poplar hybrids§	20-30	315	7.3	71	
	Shipmast robinia *Robinia pseudoacacia*†	20				
20	Hazelnut (Yield: 7-18kg/tree)	10	100			
	Almonds (Yield: 10kg/tree)	10-15	150-330			
Yields from thinning. Pollarding, coppicing at 15 year intervals.	Macadamia (Yield: 30-70kg/tree)	10-15	200			
	Pecan (Yield: 100kg/tree)	15-20	100			
	Walnuts (Yield: 150kg/tree)†	15-20	150			
	Chestnut (Yield: 180kg/tree)†	15-20	150	10		
	White oaks (Yield: 1-900kg/tree)§	15-20	200	10		
	Ash *Fraxinus excelsior*§	20		17	131-274	
	Elm *Ulmus spp.*§	20		18		
	Red oak *Quercus rubra*§	12	1511	5	95	
	Poplar hybrids§	38	216	16.8	298	
30	South American alder§ *Alnus acuminata*	45-50	2-300	19	400-500	*1100-n.a.*
Early pioneer canopy tree yield.	Poplar hybrids§	51	149	20	464	*600-n.a.*
	Shipmast robinia§	40-45	2-300	18	400-500	*1200-n.a.*
	Pine, *Pinus radiata*†	47	292	5-25	465	*53*(stumpage) *100-280*[30]
	Podocarpus totara†	17		3.5		
40	*Harvest. Consider planting mid and late succession trees*					
Pioneer canopy tree yield.	*Poplar hybrids*§	*59*	112	19.8	545	*600*-n.a.
	Shipmast robinia	45-50	900	17	400	*1200*-n.a.
	Red alder *Alnus rubra*§	45-55				*1000-2200*
	Tas. Blackwood *Acacia melanoxylon*†	40-50	100	5-6.5	175-235	1600
	Sycamore *Acer pseudoplatanus*§	45		16		*1000*† -5740§
	Rowan *Sorbus aucuparia*§	40		>10		*1200*-n.a.
	Bird cherry *Prunus avium*§	40-50	150	8	240-280	1200–1400

25 **Tree yields**: Coloured: harvestable trees. No colour: tree data from young stands.

† **New Zealand** measurements and price range (FRI, 1989; Ledgard and Giller, 1998; Pardy, Bergin, Kimberley, 1992; Bergin, 1992, 2005; Timber merchants Mark McKenzie, McAlpines Rotorua and Mike Esson; Rural Forest Systems, NZ Forestry Consultants; Laurie A 2001; MoF, 1998;)

§ **European** measurements from stands growing from 50-55° northern latitude and clear wood prices converted to NZ\$ (Dengler, 1992).

Table 12: Perpetual yields from ecological succession silviculture						
Yield in years after forest establishment	**Tree yield continuity.[25] Data from:** **• Warm temperate NZ sites†** **• Cool temperate German sites§**	**DBH[26] Target (45->60cm)**	**Stocking (Stems/ha)**	**M.A.I.[27] (m^3/ha/yr)**	**Stand volume[28] (m^3/ha)**	**Timber price range(NZ \$/m^3)[29]**
40 *continued*	Black alder *Alnus glutinosa*§	21		18	228	
	Red oak§	25	439	19.8	186	
	Black maire *Nestegis cunninghamii*†	24				
	Totara† *Podocarpus totara*	21-30				
	Kauri *Agathis australis*†	27-35				
	Rimu *Dacrydium cupressinum*†	29-32				
	Kahikatea *Dacrycarpus dacrydioides*†	29				
	Tanekaha *Phyllocladus trichomanoides*†	16-21				
	Matai *Prumnopitys taxifolia*†	17				
	Red beech *Nothofagus fusca*†	32-44		8-9		
	Black Beech *N. solandri*†	34		8-9		
	Silver beech *N. menziesii* †	30-32		7-8		
	Puriri *Vitex lucens*†	29-31				
	Mangeao *Litsea calicaris* †	37				
	Rewarewa *Knightia excelsa*†	27				
	Pohutukawa *Metrosideros excelsa*†	40				
50	Black walnut *Juglans nigra*†	45-50				*1600*-n.a.
Early mid	Bird cherry *Prunus avium*§	50-60		18	>300	*1200*-1400† 7400§
succession	Elm *Ulmus glabra*§	50-60				*1200*-1800† 4000§
canopy tree	Red oak†	45-50				*1100*-n.a.
yield	Totara†	27-40		7.7		
	Harvest. Consider planting mid and late succession trees					
60	European oak *Q. robur*†	60+	70	5-8	180-300	*1200*-2400† 6000
	Sessile oak *Quercus petraea*§	50-60		6-8	232	*1200*-2400† 6000
Mid	Ash§	50-60		8-10	274	*1000*-2200† 4000
succession	Chestnut†	60+	70	7-8	180-300	*1200*-2200†
canopy tree	Elm *Ulmus procera*†	60+	70	8-10	270-360	*1200*-1800† 4000
yield	Walnut *Juglans regia*†	50-60	70	5-7	180-300	*1600*-2200†
	Red beech †	50-55		8-9		*1000*-n.a.
	Black beech †	*50-60*		*8-9*		*1000*-n.a.
	Puriri †	62-72		7-10		*1600*-n.a.
	Red oak §	38	235	9	270	
	Black alder§	30		9	283	
	European beech *Fagus sylvatica*§			5.1	238	
	Linden *Tilia cordata*§			11.5		
	Silver beech†	46				
	Kauri (sapwood)†	50	700-1200		735	
	Kahikatea†	42-53				
	Rimu†	40				
	Totara†	11-43		2-9.3	110-470	
	Tanekaha†	36				
	Mangeao †	52				
	Pohutukawa†	51				
	Rewarewa†	42				
	Harvest follows mast seeding year. Consider re-planting pioneer and late succession trees					

26 DBH: **Diameter at breast height** (1.4 m); Clears grade logs are from trees with DBH from 45 to over 60cm.

27 M.A.I.: **Mean Annual Increment**. The average volume increase for each year.

Table 12: Perpetual yields from ecological succession silviculture						
Yield in years after forest establishment	Tree yield continuity.[25] Data from: • Warm temperate NZ sites† • Cool temperate German sites§	DBH[26] Target (45->60cm)	Stocking (Stems/ha)	M.A.I.[27] (m^3/ha/yr)	Stand volume[28] (m^3/ha)	Timber price range(NZ $/$m^3$)[29]
80 *Indigenous succession tree yields*	Hickory§	60+				>2200
	Ash§	60+			348	*1000-4000*§
	Black walnut§	60+			350	>2200
	Red oak§	60+	153	9.2	351	*1000-4000*§
	Red beech *N. fusca*†	70+		8-9	200-500	*1000*-n.a.
	Hard beech *N. truncata*†	65+		8-9		*1000*-n.a.
	Black beech *N. solandri*†	64-70+		8-9		*1000*-n.a.
	Silver beech *N. menziesii*†	66		7-8	200-500	*1000*-n.a.
	Totara (male)†	59-80		13		*1100*-n.a.
	Puriri†	70+				*1600*-n.a.
	Kohekohe *Dysoxylum spectabile*†	60-70+				*1600*-n.a.
	Mangeao †	70+				*1600*-n.a.
	Rewarewa†	60+				*1100*-n.a.
	Pohutukawa†	60+				*1600*-n.a.
	Black alder§	37		8.2	313	2000
	Black maire *Nestegis cunninghamii*†	55				
	Kauri (sapwood)†	60	100-700	5-12		
	Harvest follows mast seeding year. Consider re-planting pioneer and mid succession trees					
100	Ash§	70+		6	384	*1000-4000*§
	Red oak§	62	111	9.4	430	*1000-4000*§
	Linden§	70+		10.7		*1000*-4000
	Rimu (male)†	60- 70				*1500*-n.a.
	Kahikatea (male)†	70+				*750*-n.a.
	Black maire †	60-70+				*1600*-n.a.
	Kohekohe†	70+				*1600*-n.a.
	Pohutukawa†	70+				*1600*-n.a.
	Rewarewa†	70+				*1600*-n.a.
120	Sessile Oak§	70+		6.8	385	*2200*-6000
	European beech§	70+		8.6	552	*1000*-4000
	Tanekaha†	70+				*1500*-n.a.
200	Tawa†	50		1-3	50-200	*1600*-n.a.
	Rimu (male)†	80				*1500*-n.a.
	Miro (male)†	70+				*1500*-n.a.
	Matai (male)†	70+				*1500*-n.a.
	Kauri (heartwood)†	70+				*1500*-n.a.
	Sessile Oak§	100		5-7	550	up to 45000§
	Harvest follows mast seeding year. Consider planting mid and late succession trees					

28 **Estimate forest capital per hectare** of planted forest by multiplying the **stand volume** with the **timber price range** (next column). Financial returns: A 60cm DBH tree typically contains 2-4m^3 of merchandisable timber.

29 **Timber price range in NZ$ for one cubic metre of rough-sawn dried wood;** range depends on timber quality.
- *Italic font* corresponds to timber above box grade. It is from young trees with little heartwood or from trees without any silvicultural tending and covers all timber that can be sawn.
- Regular font corresponds to clears grade (trees with heartwood and a straight tree trunk of 45 to > 60cm dbh).
- The **price** of fresh logs **at the skid site** (stumpage) is about one third of the price given.
- **n.a.** (Not available): This timber quality is currently not available in New Zealand.
- **No entry:** (1) Young stands. (2) No timber grown for these categories (for example durable, high elasticity pollarded or coppiced wood for posts, battens or tool handles). No associated timber-processing industry; undeveloped market. Compare with Tables 13 and 14.

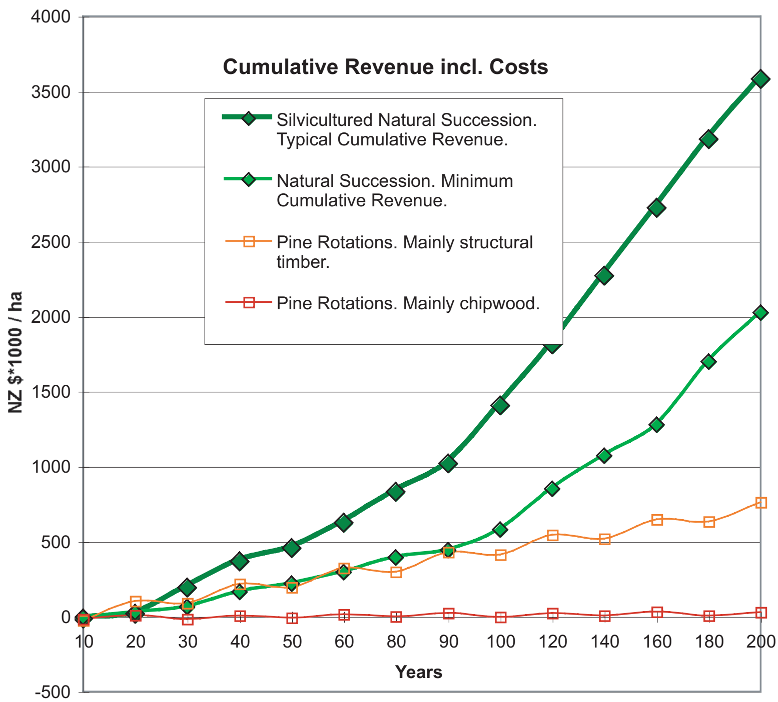
30 Timber value for pine converted from planed to rough sawn: 60% of stand volume has an average value of $277 per cubic metre in the central New Zealand, where pine plantations typically yield 40% structural and 60% industrial timber. 40% of stand volume is chip wood etc.

The following graph (Figure 156) illustrates timber revenue forecasts based on timber prices from 2001. It includes establishment and management costs, but excludes other benefits and costs.[31] The natural succession's forecasted returns are divided into:

- **Typical revenue**, expected from an ecological silviculture stand, producing branch-free veneer-quality heartwood boles of at least 6-8 m.
- **Minimum revenue,** expected from untended stands producing mainly saw-logs above box-grade.

Figure 156 and Table 12 show that innovative ecological silviculture can utilise the environmental adaptations of valued exotic and native trees in a managed forest succession, creating profitable, multiple canopy-tree yield opportunities as compatible tree species push or pull each other to optimal shape.[32]

Figure 156: Timber revenue forecast including costs



31 Native afforestation silviculture can achieve cultural re-association, social benefits from a diversified skills-base, outdoor recreation, tourism and add NZ $ 5,000/ha/yr in environmental benefits, such as restoring ecosystem functions, building sustainability capital, maintaining biodiversity. Environmental and economic costs associated with fire-risk and soil-quality deterioration under repeated pine-monoculture rotations (see pages 81-4 and 124) are also not taken into account.

32 Native trees push pioneer and fast mid-succession canopy trees to desirable shape and are pulled in turn to develop into top-quality mid-succession canopy trees. *Tanekaha, rimu, kahikatea, kauri, matai, miro* push native broadleaf timber trees and eventually emerge, providing shelter for future tree generations.

Ecological silviculture programmes (native afforestation silviculture and the selection systems) substantially increase a species' stand volume and accelerate its growth-rate compared to trees regenerating naturally. They significantly enhance a site's sustainable productivity in terms of tree-vitality, faster growth-rate, quality and volume of merchantable timber per unit area.

Communities of interest emerge, show initiative and co-operate to establish permanently productive and profitable native forestry and to help maintain native biodiversity as their afforestation restores bush vitality.

Growing Common Futures

Significantly more and managed native cover is required to restore bush remnants' vitality and maintain native biodiversity. Remaining stands are too few, cut-over, degraded and inaccessible, to sustain future timber requirements and establish potential markets for quality native timbers.

Indigenous afforestation, ecological silviculture and agroforestry projects can accelerate and achieve necessary developments, but require reliable support from attuned policies and secure funding channels throughout their establishment phase.

Such projects 'grow common futures' as they enhance and secure an ecosystem's productive potential long-term, provide sustainable economic returns, achieve cultural re-association and development opportunities as well as maintain native bush vitality.

Applied empirical research and adaptive management techniques must accompany the projects to ensure anticipated sustainable development goals are achieved and maintained.

Future opportunities are scoped to establish sustainability capital and restore bush vitality by integrating local experience and ecological silviculture expertise.

Growing common futures projects are beginning to be implemented throughout New Zealand at tangata whenua, federated farmers and local authority sites.

Visit www.bushvitality.org.nz; www.landcare.org.nz and www.bush.org.nz for more information.

Kia kaha	Give it a go
Whakahokia te mauri	Regenerating the life force

Appendices : Multiple purpose trees

Table 13: Native trees and shrubs at a glance

Common name	**Scientific name**	**Environmental and farm forestry uses (except recognised biodiversity values)**	**Wood qualities and uses**
Akeake	*Dodonea viscosa*	Rapid soil erosion control; shelter; bioengineering riparian stabilization.	Widely planted as ornamental shrub. Very hard, heavy and durable wood, not fraying at edges on impact; agricultural tools, spinning tops, taiaha, canoe paddles, cabinet making; picture frames; best turned in green condition.
Black beech	*Nothofagus solandri var sol*	Efficient soil erosion control; shelter; bioengineering riparian stabilization, Honeydew production.	Durable, dense, stable wood. Cabinet making, panelling, flooring; impact handles; superb wood for turning.
Hard beech	*Nothofagus truncata*	Efficient soil erosion control; shelter, Honeydew production.	Durable, very dense and stable wood. Cabinet making, panelling, flooring; superb wood for turning.
Red beech	*N. fusca*	Efficient soil erosion control; shelter; bioengineering riparian stabilization.	Durable, dense, even texture; NZ's most stable timber; Cabinet making, panelling, flooring; superb wood for turning.
Silver beech	*Nothofagus menziesii*	Efficient soil erosion control; shelter; bioengineering, riparian stabilization.	Easily worked and dried wood (no tension wood); even texture; excellent cabinet-making wood, steam-bending qualities; brushware; furniture, flooring, interior finishes.
Black maire	*Nestegis cunninghamii*	Effective soil erosion control; bioengineering gully and riparian stabilization; shelter. Highly favoured turning wood. Fruit sought after by wild pigs.	Hard, heavy, strong and durable wood for many purposes, including substitute for metal bearings, framing, cabinet making, ornamental items.
Broadleaf	*Griselinia littoralis*	Rapid shelter; soil erosion control; bioengineering gully and riparian stabilization. Winter fruit for poultry/birds.	Soft turning wood.
Cabbage tree	*Cordyline australis*	Resilient tree. Rapid bioengineering results at exposed sites. Erosion and river control.	
Coprosma	*Coprosma repens, C. robusta*	Rapid shelter; soil erosion control; riparian stabilization. Fruit sought after by poultry/birds	
Fivefinger, lancewood	*Pseudopanax spp*	Shelter; soil erosion control; Bioengineering riparian stabilization.	Very hard wood.
Hebe	*Hebe stricta*	Rapid shelter; bioengineering soil erosion control and riparian stabilization	
Hinau, Pokaka	*Elaeocarpus spp*	Bioengineering, soil erosion control and riparian stabilization. Fruit sought after by wild pigs.	Useful medium density hardwood. Durable dark heartwood; non-durable whitish sapwood; boat building, furniture, decking, wood turning, flooring.
Kahikatea	*Dacrycarpus dacrydioides*	Flood control; riparian stabilization. Fruit sought after by poultry/birds and wild pigs.	Easily worked perishable timber without odour. Kitchen woodware; feature panelling; good turning wood.

Table 13: Native trees and shrubs at a glance			
Common name	**Scientific name**	**Environmental and farm forestry uses (except recognised biodiversity values)**	**Wood qualities and uses**
Kanuka	*Kunzea ericoides*	Rapid shelter; soil erosion control; bioengineering gully and riparian stabilization. Nectar and honey source.	Availability: small uncommon pioneer tree. Fuel use has made large trees for agricultural implements rare. Hard, strong non-durable wood, agricultural and horti-cultural implements; hammer and impact handles; elastic canoe paddles; firewood.
Kauri	*Agathis australis*	Rapid shelter; erosion control; bioengineering gully and riparian stabilization.	Re-growth wood easy to work, but less stable and durable compared to re-cycled strong wood. The latter is used for fine furniture, panelling, boat building. Excellent carving timber.
Kohekohe	*Dysoxylum spectabile*	Coastal shelter; riparian stabilization; fruit sought after by poultry/birds.	Attractively coloured, easily worked wood for furniture and cabinet making. Durable in sand.
Kohuhu, lemonwood etc	*Pittosporum spp*	Rapid effective wind break; soil erosion control; bioengineering riparian stabilization; honey.	
Kowhai	*Sophora spp*	Bioengineering: rapid and effective soil erosion control; gully and riparian stabilization; shelter; nectar source.	Small pieces for wood turning from ornamentally planted trees. External building; agricultural implements; good turning and carving wood; attractive yellow-orange colour.
Lacebark	*Hoheria spp*	Rapid shelter; riparian stabilization.	
Mangeao	*Litsea calicaris*	Shelter; riparian stabilization, nectar source. Fruit sought after by birds.	Silvery heartwood, light,strong, tough, elastic, durable, and steam bends well. Used for canoe, boat frames, sporting goods, wheel making, cooperage, flooring and interior finish.
Manuka	*Leptospermum scoparium*	Rapid shelter; soil erosion control; bioengineering gully and riparian stabilization. Manuka honey.	Availability: common native pioneer shrub. Hard, strong non-durable wood, agricultural and horticultural implements – hammer and impact handles; firewood.
Matai	*Prumnopitys taxifolia*	Future-proofing local matai population; fruit sought after by wild pigs.	Heartwood durable out of ground. Dimensionally stable; first class flooring, exterior joinery windowsill timber.
Miro	*Prumnopitys ferruginea*	Bioengineering erosion control; riparian stabilization; survival of local miro population; important winter food source; Fruit sought after by wild pigs.	Slightly stronger than rimu, not as durable and attractive. Heartwood excellent machining qualities.
Ngaio	*Myoporum laetum*	Coastal shelter; riparian stabilization, erosion control. Poisonous to stock.	Good wood turning.
NZ Flax harakeke	*Phormium tenax*	Resilient versatile plant; rapid bioengineering results at exposed sites; wind break. Erosion and river control. Nectar source.	Versatile uses for weaving; basket-making; rope fibre etc.
Pigeonwood	*Hedycarya arborea*	Riparian, erosion, shelter. Fruit sought after by birds/poultry and wild pigs.	

Table 13: Native trees and shrubs at a glance

Common name	Scientific name	Environmental and farm forestry uses (except recognised biodiversity values)	Wood qualities and uses
Puriri[33]	*Vitex lucens*	Bioengineering, effective soil erosion control and riparian stablisation. Fruit available throughout the year and sought after by birds/poultry and wild pigs. Nectar available throughout the year.	Demand has always exceeded supply. The dark brown heartwood of NZ teak is hard, heavy, stable, durable and strong. Used for all purposes requiring great strength and durability.
Putaputaweta	*Carpodetus serratus*	Bioengineering gully and riparian stabilization, erosion, shelter.	Hard, strong wood, walking sticks.
Rata	*Metrosideros robusta; M. umbellata*	Shelter; food source; erosion control; bioengineering gully and riparian stablisation. Rata honey.	Very heavy, durable and the world's second hardest wood. Attractive reddish-plum coloured wood for turning.
Rewarewa	*Knightia excelsa*	Bioengineering; effective soil erosion control; gully and riparian stabilization, shelter. Nectar source.	Very strong and attractive feature wood. Internal house mouldings, panelling; wood turning.
Rimu	*Dacrydium cupressinum*	Bioengineering, tolerates poor soil; erosion control; riparian stabilization. Fruit sought after by birds and wild pigs.	Stable heartwood, high quality exterior joinery; flooring; popular structural timber; fine furniture, panelling; most beautiful turning wood.
Tanekaha	*Phyllocladus trichomanoides*	Bioengineering, tolerates poor soil; erosion control; riparian stabilization.	New Zealand's strongest and most flexible softwood; durable; easily worked; saws machines and turns well. Koikoi; renewable parts of canoes and houses; joinery; bridge, wharf decking; boat framing; sporting goods. Bark is source of red dye.
Tawa	*Beilschmiedia tawa*	Erosion and river control plant. Fruit sought after by wild pigs.	Harvestable size at 200 yrs. Strong heart-wood, non durable. Most useful special purpose timber. Good finishing properties; attractive furniture, floor timber; Best NZ timber for turning across grain, door knobs.
Tawari	*Ixerba brexioides*	Erosion control, attractive flowers, honey.	Very hard, dense wood.
Titoki	*Alectryon excelsus*	River and erosion control plant. Shelter. Highly prized scented oil from seeds.	Attractive light to bright red hard and strong wood with good shock resistance. Not ground-durable.Used where strength and elasticity needed; axe-handles, carpenter tools, agricultural implements, panels, bent ware, furniture, wood turning.
Totara	*Podocarpus totara*	Stock shelter; erosion control; food source; bioengineering gully and riparian stabilization. Fruit sought after by poultry/birds and wild pigs.	Very durable, easily worked wood, good as a post, not as a beam. Much sought after exterior joinery timber; canoe; house piles, harbour works; fine furniture; turning; fenceposts.
Kotukutuku	*Fuchsia excorticata*	Bioengineering, rapid gully and riparian stabilization, erosion control. Rapid shelter in moist sites, shade in summer; drying sun in winter. Fruit sought after by poultry/birds and wild pigs.	Attractive soft wood of pale fawn colour with bluish streaks.Turns well when green, then rapidly dries.
Wineberry Makomako	*Aristotelia serrata*	Rapid attractive shelter, riparian stabilization, erosion control Fruit sought after by poultry/birds.	

(Pollock, 1986; Bulloch, 1995; Clifton, 1990; Cooper and Cambie, 1991; Forest Research Institute, misc. publ.)

33 Puriri's persistent year-round flowering and fruiting makes it very valuable for sustaining fragile ecological processes in fragmented forest remnants. Highly desirable timber properties and a good growth rate make puriri an excellent prospect for its commercial planting around native forest edges or into shelterwood harvested pine stands (Janssen, 1992).

Table 14: Compatible multiple-purpose trees at a glance			
Common name	**Scientific name**	**Environmental and farm forestry uses**	**Wood availability, qualities and uses**
Blackwood	*Acacia melanoxylon*	Bioengineering soil stabilization. Tolerant of wide range of sites, including nutrient-depleted pine and eucalypt forests. Interplant in such plantations Nitrogen fixing. Readily coppiced. Foliage suitable cattle fodder.	Supply shortage. Highly decorative multicolored wood. The strong, stiff and durable heartwood is golden brown with streaks of reddish brown to black. Easily worked, steam bent. Furniture, cabinet making, panelling, wood turning, boat building.
Field maple Silver maple	*Acer campestre* *A. saccharinum* *A. platanoides*	Rapid soil stabilization and improvement of slope surface; Readily coppiced shelter	Occasionally available. Compact, hard and elastic wood. Used for ship's interiors and railway carriages. Fine furniture; excellent turning qualities; music instruments; gun-stocks.
Sycamore	*Acer pseudoplatanus*	Steep land and gully erosion control. Shade-tolerant and invasive. Replace sycamore with more suitable trees and utilise the desirable wood qualities.	Readily available. Good quality light and attractive wood. Good turning and joinery wood, highly regarded for furniture manufacture, house and kitchen utensils, music instruments, interior joinery. Undervalued in NZ.
Black alder Grey alder Red alder Andean alder	*Alnus glutinosa;* *Alnus cordata;* *A. incana;* *A. rubra;* *A. acuminata*	Bioengineering: versatile and rapid soil stabilization and improvement of slope surface; *Alnus glutinosa*'s root-system vertically penetrates waterlogged sites and effectively stabilises riverbanks. Andean and red alders are amongst the fastest growing, effective soil erosion control trees; Readily coppiced; nitrogen fixing; preferred shelter (vertical roots) Better choice than pines!	Alders should increasingly become available; red alder has an easily worked wood, used for fine furniture; panelling, good firewood. *A. glutinosa* wood lasts centuries when kept wet (Venice is built on its piles). Attractive reddish, light, durable, easily worked multi-purpose wood. Fetches same price as beech timber in Germany.
Strawberry tree	*Arbutus unedo*	Bioengineering effective soil erosion control on nutrient poor soils. Readily coppiced. Edible fruit. Preserves, liquors, wines, winter food source for poultry/birds. Leaves: tanning.	Occasionally available.Tree mainly planted for amenity reasons in NZ.
Birch	*Betula spp*	A tree of life in northern forests. Water repelling inner bark used as water containers. Outer bark lights fires. Good firewood. Soil amelioration of nutrient poor sites. Sap for food (birch beer) and medicine.	Wood commonly available.Wood has good anatomical and technological attributes, for industrial purposes, used as veneer, furniture, carving, tool handles, crates and firewood.
Bottlebrush	*Callistemon spp*	Shelter on dry sites. Winter food source for poultry/birds. (Caution: fire-adapted species!)	Increasingly available. Wood qualities and uses not known.
Hornbeam	*Carpinus betulus*	Effective erosion control; Commonly planted in Europe to achieve optimal growth and timber qualities for Oak *(Q. robur)*. Readily coppices and regenerates well after stock and deer browsing.	Rarely available hard, heavy and light wood, used for special purpose.

Table 14: Compatible multiple-purpose trees at a glance

Common name	Scientific name	Environmental and farm forestry uses	Wood availability, qualities and uses
Hickory, Pecan	*Carya spp*	Effective erosion control; shelter.	Nutritious nuts for domestic and commercial enterprises; readily coppiced; domestic stock and wild pigs. Difficult to obtain. Wood of similar superior qualities to its cousin the walnut. Fine furniture; tool handles; gun-stocks; joinery; carving, wood turning.
Chestnut	*Castanea sativa*	Effective erosion control on non-alkaline soils; Rapid soil stabilization and improvement of slope surface. Drought tolerant. Extensive on-farm use as posts and poles using 9-year coppice rotations. Sought after nuts for domestic and on-farm use. Lure wild pigs and possum for effective pest control.	Very versatile tree, occasionally available, slow drying wood. High, ground-durable heartwood content. Attractive and stable wood; machines,glues and finishes well. Fine furniture; gates, domestic woodware; kitchen utensils; cabinet making; joinery; building; tool handles; vineyard and hop poles; casks for oils, fruit juices, vines, fenceposts. Flamboyant turning wood.
Catalpa	*Catalpa speciosa*	Rapid shelter; erosion control. Not browsed. Good pioneering tree in pasture. Readily coppiced. Nectar.	Occasionally available. Fine furniture; joinery; boat-building.
Carob	*Ceretonia seliqua*	Shelter on dry sites; erosion control. Food source domestic stock, pig, poultry/birds; attracting wild pigs.	Difficult to obtain.
Tree lucerne (Tagasaste)	*Chamaecytisus palmensis*	Rapid shelter; soil erosion control; bioengineering gully and riparian stabilization. Domestic supplementary stock food source.	Winter food source for birds. Generally available; coppiced or pollarded for stock fodder.
Cornell cherry	*Cornus mas*	Rapid soil stabilization and improvement of slope surface on open dry sites. Early spring flowering, late autumn fruiting. Preserves, iced juice. Domestic and supplementary stock food source.	Difficult to obtain. Hard dense attractive wood; special purpose timber; walking sticks.
Hazelnuts	*Corylus spp*	Erosion control, shelter and riparian stabilization. Good burial resistance. Frost hardy. Readily coppiced. Nuts; stock food supplement.	Occasionally available. Hard dense elastic wood. Special purpose timber.
Tamarillo	*Cyphomandra betaceae*	Rapid growth in semi-shade. Early winter food.	Occasionally available. Wood qualities and uses not known.
American Persimmon	*Diospyros virginiana*	Bioengineering soil stabilization. Edible fruit sought after by mammals and poultry/birds.	Generally unavailable: Hard strong dark brown wood; building, cabinet making, joinery, wood turning, musical instruments.
Feijoa	*Feijoa sellowiana*	Shelter; rapid erosion control. Bird pollinated. Honey and winter fruit source.	Increasingly available. Wood qualities and uses not known.
Ash	*Fraxinus excelsior*	Bioengineering gully and riparian stabilization; rapid soil stabilization and improvement of slope surface. Foliage is an original and preferred fodder for cattle and deer; readily coppiced, good shelter.	Occasionally available through wood-workers guilds. Most versatile tough, shock resistant, easily worked and steam-bendable wood. Wheel rims, carriage, sporting goods, sleds, fine furniture, chairs, gym equipment; tool handles, ply and veneer. Stable, attractive creamy-pink turning wood.

Table 14: Compatible multiple-purpose trees at a glance			
Common name	**Scientific name**	**Environmental and farm forestry uses**	**Wood availability, qualities and uses**
Walnut trees	*Juglans regia* *Juglans nigra*	Highly regarded food source; sought after by pigs and stock. Walnuts lure wild pigs and possums for effective control. *J. nigra* grows to 60cm diameter at breast height in 40-50 years.	Occasionally available (contact wood-workers guild). The attractively coloured and very durable wood is heavy, hard, strong, stiff, easily worked, shock absorbent, and stable. Fine furniture; cabinet making; joinery; tool handles, gun-stocks. Fine finishing for excellent woodturning; superior carving wood.
Apple	*Malus sylvestris* and domestic varieties	Domestic and supplementary stock food source.	Generally available; fruit; fine furniture; joinery; wood turning.
Medlar	*Mespilus germanica*	Shelter; erosion control. Vitamin-rich fruit, edible after first frost. Preserves. Winter food source; honey.	Difficult to obtain. Special purpose wood.
Mulberry	*Morus alba* *Morus rubra*	Bioengineering effective erosion control; riparian stabilization; shelter. Readily coppiced. Fruit: vitamin-rich, edible preserves. Leaves: domestic and supplementary stock and deer food source. Fruit is sought after by birds.	Difficult to obtain. Wood qualities and uses not known.
Olive	*Olea spp*	Drought-erosion control; shelter; domestic and supplementary stock food source. Sought after by domestic stock, pig, birds.	Occasionally and increasingly available. Fine furniture; finest wood turning and carving; tool handles.
Paulownia	*Paulownia tomentosa*	Rapid shelter; domestic supplementary stock and deer food source. Fragrant flowers appear before leaves. Honey.	Occasionally available. Special purpose timber; fine furniture; joinery.
Poplars	*Populus nigra* *P. deltoides* and their hybrids	Erosion control of wet soils. Rapid shelter. Hybrids grown in sheltered sites produce sawmill-ready logs in less than 20 years. Biomass and energy production on 5-15 year rotations (N. America). Readily coppiced. Domestic supplementary stock food source.	Generally available. Pale coloured, tough wood that does not split. Lacks strength or stiffness and is perishable in the ground. Shelterbelt wood notorious for tension wood, difficult to saw and easily distorts during drying. Overseas poplar is used for joinery, light structural work, truck-decks, flooring, boxes, crates, kitchen articles, veneer; match splints, pulp and wooden shoes.
Cherry, Plum, Almond, Apricot, Peach	*Prunus avium* *Prunus spinosa* *etc and domestic varieties*	Domestic and supplementary stock food source. Do well with an understorey of perennial herbs, such as host plants for insect pest predators (*Umbelliferae*); aromatic herbs (*Labiatae*), mulch producing comfrey and fruiting shrubs. Fruit sought after by wild pigs; possum lure for effective pest control.	Generally available; preserves; beautiful turning woods; special purpose timber, walking sticks, fine furniture; joinery; carving; woodwind instruments; sculpture.
Pear	*Pyrus communis*	Shelter; food source; erosion control; domestic supplementary stock, pig, poultry/birds food source.	Occasionally available through woodworkers guilds. Fine furniture; joinery; carving.

Table 14: Compatible multiple-purpose trees at a glance

Common name	Scientific name	Environmental and farm forestry uses	Wood availability, qualities and uses
White oaks	*Quercus petraea* *Q. robur,* *Q. alba,* *Q. garryana,* *Q. lobata* *Q. michauxii,* *Q. muehlen-bergii*	Excellent erosion control and bioengineering tree for riparian stabilization. Domestic and supplementary stock food source. Readily coppiced. For good form commonly associated with slightly slower growing natives trees, in European forestry with linden (*Tilia spp)* or hornbeam (*Carpinus betulus*).Sought after by domestic pigs, cattle (*Q. mic*), birds (*Q. mue*) and a lure for wild pigs.	Good oak logs are few and far between. Contact local woodworkers guild. Strong, durable and attractive wood of supreme quality. Very good steam bending properties. Used for house and boat building; wheel spokes, cabinet making, important furniture wood, wine cooperage, joinery; panelling, domestic floors; Wood turning; tool handles.
Shipmast robinia	*Robinia pseudoacacia*	Bioengineering effective soil erosion control gully and riparian stabilization. Tough, extensive root system. Readily coppiced. Good nectar source for bees.	Very versatile fast growing, multi-purpose tree. Popular plantation tree from France to China. The new Hungarian variety (here since 1982) produces saw-logs within 30 years. Older material from crooked trees is available. Strong very durable, shock resistant and steam bendable heartwood. Garden furniture; ground contact building, agricultural implements, tool handles; ladder rungs, parquet flooring, panelling, exterior cladding, laminated beams, veneer, fence posts; poles; railway sleepers; good firewood; wood turning.
Willows	*Salix alba* *Salix viminalis* etc.	Bioengineering riparian stabilization; rapid shelter; soil erosion control. Honey.	Willow wood is freely available. The basket willow *S. viminalis* is pollarded at head height in northern Europe, to protect new shoots from stock. Basket weaving, wickerwork, firewood.
Rowan	*Sorbus aucuparia*	Bioengineering: rapid soil stabilization and improvement of slope surface. Readily coppiced. Effective shelter. Vitamin-rich fruit, best after first frost. Preserves, winter food source for poultry/birds.	Occasionally available. Common use as amenity or pioneering shrub to stabilise hill slopes under-utilises its value as a potential 20m forest tree. Very attractive white to reddish-brown heavy, easily worked, dried, polished timber. Veneer. High quality furniture; flooring, wood turning; tool handles.
Linden-lime	*Tilia spp*	Shelter; erosion control. Readily coppiced, fairly shade-tolerant Medicinal; sought after honey.	Occasionally available. Special purpose timber. Fine furniture; joinery.
Elm	*Ulmus procera* *Ulmus glabra*	Bioengineering riparian stabilization; rapid shelter; soil erosion control. Readily coppiced. Rapid grower, tends to spread when open grown, needs training with trees of similar growth rate for good tree trunk. Highly nutritious leaves. Foliage is an original and preferred fodder for cattle and deer, kereru love it for the same reason.	Available occasionally through wood-workers guild. Potential export timber. Wood lasts centuries when kept wet. Interlocked grain provides stability against splitting and was used for the wheel hub since its invention, for pulleys of ships' tackle, boat bottoms, planking, rudders and fenders. Fine furniture, cabinet-making, chairs; interior trim, excellent turning, sculpting wood (burrs of interesting grain).

(Pollock, 1986; Bulloch, 1995; Clifton, 1990; Cooper and Cambie, 1991; Forest Research Institute, misc. publ.)

Information sources

P Thomson, DOC

Funding assistance

Funding assistance is available from a variety of sources, though each agency has its own priorities. A well thought out bush restoration strategy demonstrates your commitment and appreciation of what needs to be done and why you need the assistance. This will help you secure funding.

National, regional and territorial authorities, environmental organisations, lottery grants and private sponsors all support environmental outcomes initiated and driven by local community initiatives.

- The Bio-Community Web (National Biodiversity Strategy) and Landcare groups share restoration experience, www.commonground.co.nz/BioCommunity/static/whatis.htm

Funds are available for legal site protection and fencing from the:

- Department of Conservation:www.doc.govt.nz
- Queen Elizabeth II Trust: www.nationaltrust.org.nz

Biodiversity Condition Funds are available to community groups or individuals involved in the restoration of legally protected biodiversity sites.

- Ministry for the Environment, sustainable management fund: www.smf.govt.nz
- Ministry of Agriculture and Forestry sustainable farming fund: www.maf.govt.nz/sff
- Department of Internal Affairs, community grants, lottery grants, environmental heritage fund: www.dia.govt.nz
- Ministry of Economic Development: www.med.govt.nz/irdev/reg_dev

Regional Councils offer environmental grants to support biodiversity restoration and sustainable land management and seek to initiate such projects at prioritised sites.

Local community trusts may manage or fund biodiversity restoration projects.

Internet information

Background information

- Bush Vitality interactive website: www.bushvitality.org.nz
- Bird identification: www.whatbird.co.nz
- World's Biodiversity Hotspots: www.conservation.org/xp/CIWEB/strategies/hotspots/hotspots.xml
- Convention on Biological Diversity: www.biodiv.org/convention/articles.asp
- New Zealand Biodiversity website: www.biodiversity.govt.nz/
- New Zealand Ecological Society: www.nzes.org.nz/index.html
- Conservation Ecology for Practitioners and Scholars: www.consecol.org/Journal/
- Genuine Progress Index (GPI), Measuring sustainable development: The Nova Scotia Genuine Progress Index. www.gpiatlantic.org/ab_sustain_nsgpi.shtml; www.rprogress.org/projects/gpi/ ; www.flora.org/economicgood/GPI.html; www.adbusters.org/campaigns/question/toolbox/ gpivsgdp.html
- The free encyclopedia www.wikipedia.org

Government agencies

- Regional and local governments: www.lgnz.co.nz/localgovt/councils/
- Department of Conservation: www.doc.govt.nz
- Parliamentary Commissioner for the Environment: www.pce.govt.nz/
- Ministry for the Environment: www.mfe.govt.nz
- Ministry of Agriculture and Forestry: www.maf.govt.nz/mafnet/
- Environmental Performance Indicator Programme: www.environment.govt.nz
- What can you do to help our biodiversity: www.mfe.govt.nz/withyou/do/biodiversity.html
- Globe Teacher's Guide: archive.globe.gov/globe_flash.html; archive.globe.gov/sda-bin/wt/ ghp/tg+L(en)+UP(landcover/Contents
- Biodiversity on Private land: www.mfe.govt.nz/issues/biodiversity/responsibilities/private-land/
- *Incentives for sustainable land management. Community cost sharing to conserve biodiversity on private land. A guide for local government.* Australia. www.environment.gov.au/bg/bushcare/publications/ incent.htm

Protection and projects

Protecting native biodiversity on private land:

- Queen Elizabeth II Trust: www.nationaltrust.org.nz/
- Nga Whenua Rahui: www.doc.govt.nz/Community/007~Conservation-on-Private-Land/003~Nga-Whenua-Rahui.asp
- Nature Heritage Fund: www.doc.govt.nz/Community/007~7EConservation-on-Private-Land/001~7ENature-Heritage-Fund.asp
- New Zealand Plant Conservation Network: www.nzpcn.org.nz
- Plant pest information: (MAF); www.protectnz.org.nz/; EBOP: www.boprc.govt.nz/green/weeds.htm

Communicate your projects and exchange ideas:

- www.biocommunity.org.nz/
- www.bush.org.nz
- www.bushvitality.org.nz
- www.landcare.org.nz

Practitioners' links

Matching multipurpose trees to your site

- Tane's Tree Trust. The Trustees come from a variety of scientific, forestry, nursery and farming backgrounds. All are top people in their fields. Tane's Tree Trust's vision is "To see the majority of New Zealand landowners successfully planting and sustainably managing indigenous trees for multiple uses by 2020". www.tanestrees.org.nz/
- Landcare Trust facilitating sustainable management and biodiversity initiatives with rural communities: www.landcare.org.nz
- New Zealand Tree Crops Association: www.treecrops.org.nz/tcalinks.html
- New Zealand Farm Forestry Organisation: www.nzffa.org.nz/main.html
- Plants for a future databases: www.ibiblio.org/pfaf/D_search.html or www.comp.leeds.ac.uk/pfaf/index.html
- The Green Toolbox – free decision support software to help choose and evaluate plants for a variety of land management applications: www.landcareresearch. co.nz/research/biodiversity/greentoolbox/index.asp
- New Zealand Plant database: nzflora.landcareresearch.co.nz
- Tree planting for native birds: www.doc.govt.nz/Conservation/001~Plants-and-Animals/Tree-Planting-for-Native-Birds.asp
- Crop and Food regularly publishes research information about the economic potential of new plants in New Zealand: www.crop.cri.nz/what/sectors.htm
- New Zealand Forest Research Institute is developing management options and growth and silviculture models for species, including kauri and totara in planted and natural second growth stands. Of the hardwoods, rewarewa and puriri are comparable to some of the best exotic hardwoods: www.scionresearch.com.
- Department of Agriculture Western Australia has developed an Agroforestry Calculator. It is a simple computer program that makes it easy for farmers and their advisers to estimate the profitability of agroforestry projects at the paddock scale. Expected profits from agroforestry can be compared with current agricultural gross margins. www.agric.wa.gov.au/environment/tools/trees/Agroforestry_Calculator.htm
- Tree crops and agroforestry in America: www.daviesand.com/Papers/Tree_Crops/index.html
- Alley cropping; silvo-pasture, riparian and windbreaks: web.missouri.edu/~afta/About_AF/AC1.htm
- International Organic Farming: www.ifoam.org/
- Permaculture links: www.permacultureinternational.org/index.htm
- Soil and Health Association NZ: www.soil-health.org.nz/
- Farming links: www.newzealandsites.com/science/agriculture-and-horticulture/ www.farmnews.co.nz/; www.lifestyle-farmer.co.nz/; www.smallfarmer.org.nz

Further reading

Identification

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Glossary

80/20 rule: *See* Law of diminishing returns.

Adaptive management: An experimental approach to management, or "structured learning by doing". It is based on developing dynamic models that attempt to make predictions or hypotheses about the impacts of alternative management policies. Management learning then proceeds by systematic testing of these models, rather than by random trial and error. Adaptive management is most useful when large complex ecological systems are being managed and management decisions cannot wait for final research results (compare agroforestry and reafforestation models).

Agricultural land: Land used for production of food and fibre. It includes dairy, sheep, beef, other livestock, horticulture, cropping, vegetable production and fruit growing.

Agroforestry: is a collective term used to describe a wide range of sustainable land use practices that integrate trees, shrubs, perennial crops or grazing for multiple purposes. Such production systems can be centuries old or latest sustainable enterprises. New technologies and crop combinations are trialled around the world to surprising effect in terms of achieving maximum productivity and sustaining ecosystem processes. (compare ecological footprint; permaculture)

Annual: A plant completing its lifecycle within one year (compare perennial).

Biodiversity: The variability among living organisms from all sources, including diversity within species, between species and of ecosystems. Components include:

- **Genetic diversity:** The variability in the genetic make up among individuals within a single species. In more technical terms, it is the genetic differences among populations of a single species and those among individuals within a population.
- **Species diversity:** The variety of species – whether wild or domesticated – within a particular geographical area. A species is a group of organisms which have evolved distinct inheritable features and occupy a unique geographic area. Species are usually unable to interbreed naturally with other species due to such factors as genetic divergence, different behaviour and biological needs, and separate geographic location.
- **Ecological (ecosystem) diversity:** The variety of ecosystem types (for example, forests, deserts, grasslands, streams, lakes, wetlands and oceans) and their biological communities that interact with one another and their non-living environments.

Bioprospecting: The search among biological organisms for commercially valuable compounds, substances or genetic material.

Bioregion: A bioregion (short for biogeographic region) is an area that is defined according to patterns of ecological characteristics in the landscape or seascape. It provides a framework for recognising and responding to indigenous biodiversity values.

Biosafety: The policies and actions taken to manage risks from the intentional introduction of new organisms, including genetically modified organisms that could adversely affect biodiversity, people or the environment.

Biosecurity: The protection of people and natural resources, including biodiversity, from unwanted organisms capable of causing harm.

Biota: All the living organisms at a particular locality.

Community: The biotic component of an ecosystem. The organisms interact (by competition, predation, mutualism etc.) and give the community a structure.

Cohort Each aggregation of trees that start as a result of a single disturbance / initiative is a single-cohort. A cohort has an effective age, even if the chronological age varies widely. A multiple-cohort stand contains at least three age-classes intermingled intimately on the same area (*See* ecological silviculture; Plenterwald, selection system)

Compatible plant species: Many exotic plants are compatible with native ecological processes. Such plants will not invade healthy bush patches, but rather prepare the way for native regeneration. (Compare strategy; succession; ecosystem processes; humus type – mull.)

Conservation: As defined in the Conservation Act 1987 (in respect of conservation areas), the preservation and protection of natural and historic resources for the purpose of maintaining their intrinsic values, providing for their appreciation and recreational enjoyment by the public, and safeguarding the options of future generations. In the Biodiveristy Strategy (as in the Convention on Biological Diversity), the term conservation is used in a broader sense than in the Conservation Act. While distinguished from "sustainable use" and "sustainable management", conservation embraces both the protection and judicious use and management of biodiversity for the benefit of human society and for ethical reasons, including its intrinsic value and its importance in maintaining the life-sustaining systems of the biosphere.

Continuous cover forestry: An ecological silviculture programme that maintains a site's forest cover as trees are harvested by selection systems and shelterwood methods.

Convention on Biological Diversity: An international agreement on biological diversity that came into force in December 1993. The objectives of the Convention are: the conservation of biological diversity; the sustainable use of its components; and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources.

Corridor: A linear landscape element that differs from the matrix on either side.

Cultivar: A cultivated variety (genetic strain) of a domesticated crop plant.

Data: The facts that result from direct observations or measurements. They can take the form of raw results from monitoring – such as the number of species in a particular area.

Deciduous: Shedding all its leaves seasonally. (such as tree fuchsia; wineberry; many northern hemisphere broadleaf trees)

Dioecious: Male and female flowers are on different plants. (Compare monoecious, hermaphrodite and unisexual)

Discounting: The process of finding the current value of an amount of cash at some future date. A major issue in economics is to set an appropriate discount rate to account for future environmental effects. *See* market failure.

Dispersal: On reaching maturity young animals move from parent's territory in order to establish their own territory.

Divaricating: Spreading at a very wide angle; usually shrubs and juvenile trees with stiff, inter-tangled branching

Domesticated or cultivated species: Species in which the evolutionary process has been influenced by humans to meet their needs (Convention on Biological Diversity). They include both introduced and indigenous species that have been domesticated or cultivated.

Ecological carrying capacity: Refers to the number of people that an area of productive land can support.

Ecological District: A local part of New Zealand where the features of geology, topography, climate and biology, plus the broad cultural pattern, inter-relate to produce a characteristic landscape and range of biological communities unique to that area. Two hundred and sixty-eight Ecological Districts in New Zealand have been identified and mapped (at 1:500 000 scale).

Ecological footprint An ecological footprint measures how much land is required to supply a particular country, region, city, business or individual with its living and lifestyle needs – that is food, housing, energy/fuel, transport, and consumer goods and services. The larger the footprint, the more resources are needed to support that lifestyle. The ecological footprints of most developed countries require more land than is available. New Zealand is no exception. While New Zealand's footprint is smaller than that of the United States (by 46%), Denmark and Australia, it is over eight times larger than India's and significantly larger (25-30%) than the footprints of Germany, the United Kingdom, the Netherlands and Japan.

Ecological footprint per capita: The amount of productive land required by an individual in a population to support their consumption. This is usually an average of the national footprint. 8 hectares are required to support the lifestyles of each New Zealander (with adjustments for land productivity). Historically acres were used to allocate land to sustain families. One acre was considered sufficient to sustain one family.

Ecological functions: Are considered good when an ecosystem can sustain all indigenous species which occur naturally within it, including those most sensitive to the effects of human activities (and of pests and weeds). Parameters include indicator and keystone species richness, habitat size.

Ecological overshoot: If a population uses more land to support it than is available, it is said to overshoot its carrying capacity. The amount of productive land available does not sustain that population (New Zealand's 4 million inhabitants as at 2004 will overshoot New Zealand's ecological carrying capacity within a decade at a proposed 4% GDP increase/year, while at present level of consumption New Zealand could sustain about 6 million people).

Ecological silviculture (oekologischer Waldbau) or '**Plenterwald'.** A multiple-cohort and multiple-species stand, managed using the 'selection system' and applying natural forest ecosystem processes. A Plenterwald results from indigenous people's forest management as it passes from one generation to another, providing sustainable production for local communities, while achieving the resilience and benefits of a natural forest ecosystem (*See* cohort, selection system).

Economic value: Economic value may be assigned according to the following components:

Direct use value: The value of all goods and services derived from the direct use of biodiversity.

Indirect value: The value derived from services from biodiversity (ecosystem services) that protect and support direct use activities.

Passive value: The value of biodiversity in terms of potential future uses (option value), its existence for its own sake (existence value), and the willingness of present generations to pay to preserve biodiversity for the benefit of future generations (bequest value).

Ecosystem: A dynamic system of plants, animals and micro-organism communities and their non-living environment (such as sunlight, air, water, minerals and nutrients) interacting as a functional unit.

Ecosystem/Habitat fragments: Remnants of once more extensive habitats or ecosystems in a production landscape (compare extinction dept).

Ecosystem health/integrity: An ecosystem, which is stable and sustainable, maintaining its organisation and autonomy over time and its resilience to stress. Ecosystem health can be assessed using measures of resilience, vigour and organisation.

Ecosystem management: A management philosophy intended to sustain the integrity of ecosystems.

Ecosystem processes: Ecological processes organize regeneration, natural succession, community structure and composition towards a resilient, functional ecosystem. Evolved functional links, nutrient cycling and conservation strategies and energy flow, food webs (of producers, consumers and decomposers), symbioses (*See* keystone species), habitat structure and community composition are measurable ecological process indicators of particular ecosystems.

Ecotone: A narrow, defined transition zone between two or more different communities. Ecotones arise naturally at land-water interfaces. Natural edge communities are typically species-rich.

Ecotope: The natural habitat component of an ecosystem. (For example: swamp-forest; rush land and lake are ecotopes of a wetland ecosystem and distinct habitats for different species).

Ecotype: A locally adapted population of a widespread species. Such populations show minor genetically induced changes of morphology and/or physiology. This is often in response to the range of environmental conditions and diverse ecosystems a species inhabits. Such genetic diversity often improves a species' resilience and is one reason for eco-sourcing of plant material (compare population; genetic erosion).

Edge: The outer band of a patch that has an environment significantly different from the interior of the patch. Competition with and predation of native species by exotic pests is particularly high in terrestrial edge habitats in New Zealand.

Endemic species: An indigenous species, which occurs only in New Zealand and nowhere else (for example Kiwi and over 80 % of native plants). A local endemic species breeds only within a specified region or locality and is unique to that area. (Compare indigenous species.)

Environment: Ecosystems and their constituent parts, including people, communities and all natural and physical resources.

Environmental domains: Areas with similar physical environmental conditions, as defined by factors (including solar radiation, temperature, moisture and geological substrate) that have been demonstrated to have high correlations with plant and animal distributions.

Environmental education: A multi-disciplinary approach to learning that develops the knowledge, awareness, attitudes, values and skills that will enable individuals and the community to contribute towards maintaining and improving the quality of the environment.

Epiphyte: Plant perching upon another but neither penetrating it nor drawing nutrients from it (contrast with parasite)

Exotic: *See* Introduced species.

Extinct: Applied to a taxon, no member of which is living at the present time (for example Huia)

Extinction debt: Some individuals of most populations survive initial habitat loss. Small remaining populations in fragmented habitats are subject to new pressures (food shortage, discontinuity of food supply, increased predation and competition). Many remaining animal and plant populations eventually succumb to these unprecedented pressures, resulting in an increasingly impoverished remnant that is a mere shadow of the original ecosystem.

Feral species: A domesticated species that has become wild (feral cats).

Fire climax plant species: Plants that establish a lasting fire tolerant climax community. Generally versatile pioneering plant species with remarkable nutrient mining strategies, tolerant of nutrient-poor soils, mostly light demanding (pines, eucalypts), sometimes shade tolerant (Douglas fir). Flammable litter builds up over soil and eventually burns. Fire climax species are adapted to either survive fires or regenerate profusely following intense fires. Regenerating native species that could shade out light-demanding fire climax species' progeny are usually killed, so that only fire-adapted species regenerate and persist as a climax community. Successful examples of this strategy: eucalyptus dominance in Australia; Douglas fir dominance in Western N. America and various pine belts in the northern hemisphere; (*See* humus type – mor; strategy; pests)

Flock: Refers to birds that congregate in large numbers for migration in autumn.

Fragmentation: *See* ecosystem/habitat fragments.

Fundamental niche: Full range of habitats a species could occupy, including site with optimal growth conditions (*See* realised niche).

Gene: The functional unit of heredity; the part of the DNA molecule that encodes a single enzyme or structural protein unit.

Genetic diversity: *See* Biological Diversity.

Genetic erosion: Loss of genetic diversity between and within populations of the same species over time; or reduction of the genetic basis of a species due to human intervention or environmental changes, often caused by extinctions of locally adapted populations.

Genetic material: All or part of the DNA of a genome or all or part of an organism resulting from expression of the genome.

Genetic resources: Genetic material of plants, animals or microorganisms (including modern cultivars and breeds, primitive varieties and breeds, landraces and wild or weedy relatives of crop plants or domesticated animals) that has value as a resource for people or future generations.

GPI: The Genuine Progress Index is based on the fundamental understanding that social, economic and environmental realities are inextricably linked and that long-term prosperity and well-being are ultimately dependent on the protection and strengthening of our social and environmental assets. If these deteriorate, we are not living sustainably. The Genuine Progress Index also recognises that any index of progress is value-based and must answer the question 'progress towards what?' The use of the Gross Domestic Product as a measure of progress is also value based, and assumes that more is always better. By contrast, the GPI adopts a set of broader consensus values in which less may sometimes be better, as in the case of crime, pollution and sickness.

Genus: A classification category above the level of species and below family. (Pl. genera)

Gondwana (or Gondwanaland): The southern supercontinent that started to break up about 150 million years ago, consisting of what are now South America, Africa, Antarctica, Arabia, Australia, India, Madagascar and New Zealand.

GDP: Gross domestic product is used to compare the size of economies. It is a measure of the market value of goods and services produced in a given period irrespective of its quality, sustainability or purpose.

Group-selection system. The final age-class consists of two or more single mature trees of one or more species. The regeneration openings can accommodate the ecological requirements of almost any tree species. It is practical and efficient if more light-demanding species are to be managed or re-introduced, such as *beech, rata, rewarewa, kowhai*. It replicates the gap-phase regeneration of many late-successional temperate forest ecosystems. (*See* selection system).

Habitat: The natural living space of an organism, characterised by its physical or biotic properties.

Habitat fragmentation: *See* ecosystem/habitat fragments.

Habitat node: A habitat node or key native ecosystem can refer to habitats, ecotopes or ecosystems. It is characterised by high functional intactness and resilience due to keystone and indicator species diversity and richness. Its natural local populations have the potential to consistently produce surplus individuals that can disperse (*See* dispersal) and become source populations in neighbouring, less resilient sites. Biodiversity inventories and research seek to find habitat nodes to prioritise their comprehensive restoration.

Hapu: Maori family or district groups, communities, a sub-tribe.

Hedging: Term used to assess possum browse-damage on totara. The canopy has a windshorn appearance on the leeward side of the tree and in trees on sheltered sites. Windshorn appearance on the exposed windward side may be natural. Browsing of new season's light green shoots leaves a canopy with the dull green colouration of older totara leaves.

Hermaphrodite flower: Having both stamens (pollen producing male reproductive organ) and carpels (female reproductive organ) within a single flower. Distinct female receptive phase usually prevents self pollination. (compare unisexual, monoecious and dioecious).

Humus types:

- **Mull humus** develops from litter that readily decomposes, such as from many native and exotic deciduous trees, legumes and herbs. Seasonal litter decomposition by earthworms etc, firmly bonds humus and clay minerals, resulting in high nutrient and water storage and exchange capacities and friable topsoil. Typical pH 5-7.
- **Moder humus** develops from low fertility grasses, beech and kanuka litter. Typical pH 4-5.
- **Mor humus** develops from plant litter resisting decomposition, such as from pine, eucalypt, heather, kauri. Acidic humus (pH 3-4) typically leaches through soil profile resulting in lowering a soil's nutrient and water storage and exchange capacities.

Incompatible plants: Are usually long-lived exotic plants (trees) that can out-compete native trees in having superior tolerance levels to shade/ fire/ desiccation (drought) or temperature. Over time, they can invade and replace native ecosystems. Pines can rapidly colonise tussock lands. Native forest remnants are at risk from desiccation, forest fires (eucalypts and pines) and invasion by some shade tolerant and competitive exotic conifers (Douglas fir; firs, hemlocks). (Compare compatible; fire climax; humus type – mor; pests).

Indicator: A measure (for example, distance from a goal, target, threshold or benchmark) against which some aspects of performance can be assessed. The use of an indicator enables the significance of a statistic to be determined, for example, the extent to which an objective is met.

Indicator species: A species whose presence or absence is indicative of a particular habitat, community or set of environmental conditions. In the context of this book it refers to species expected to be present, which however are vulnerable to predation or browsing. Their absence or browse damage indicates pest pressures.

Indigenous species: A plant or animal species, which is self-introduced and occurs naturally in New Zealand. Some indigenous species may also occur outside of New Zealand (Welcome Swallow; Silvereye). A synonym is "native". (Compare endemic species).

Indigenous natural vegetation: Any local indigenous plant community containing throughout its growth the complement of native species and habitats normally associated with that vegetation type or having the potential to develop these characteristics. It includes vegetation with these characteristics that has been regenerated with human assistance following disturbance, but excludes plantations and vegetation that have been established for commercial purposes.

Information: Data that has been organised, integrated, and to some extent analysed. It is data that is made meaningful as a result of collection, processing, organisation and interpretation in light of some hypothesis.

In-situ conservation: The conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties (Convention on Biological Diversity).

Introduced species: A plant or animal species, which has been brought to New Zealand by humans, either by accident or design. A synonym is "exotic species".

Intrinsic values: In relation to ecosystems, means those aspects of ecosystems and their constituent parts, which have a value in their own right, including their biological and genetic diversity and the essential characteristics, that determine an ecosystem's integrity, form, functioning and resilience.

Invasive species: An animal pest or weed that can adversely affect indigenous species and ecosystems by altering genetic variation within species, or affecting the survival of species, or the quality or sustainability of natural communities. In New Zealand, invasive animal pests or weeds are almost always species that have been introduced to the country (*See* fire climax plant species, pests.)

Invertebrate: An animal without a backbone or spinal column, such as insects, spiders, worms, slaters. Invertebrates make up the vast majority of all animal species.

Iwi: Maori tribal grouping.

Key native ecosystem: Native ecosystem with comparatively intact ecological functions. *See* habitat node; ecological function; ecosystem processes.

Keystone species: In the context of this book it refers to species with numerous important symbiotic links to other species. The local extinction of which undermine the vitality of dependent local populations. Keystone species are found in plants, insects, fungi, and birds. They have a prominent role, often as symbiotic organisms, in sustaining ecosystem processes

Knowledge: The theoretical or practical understanding, knowing and familiarity gained by experience.

Landcare Research: Manaaki Whenua/Landcare Research is the New Zealand Crown Research Institute that focuses on management of land resources for conservation and for primary production.

Landscape: A heterogenous land area composed of a cluster of interacting ecotopes or landscape elements that are repeated in a similar manner throughout.

Landscape element: The basic relatively homogenous unit, whether of natural (ecotope) or human origin (city; agriculture, reliant on external input and output), on land at the landscape scale.

Law of diminishing returns: The tendency for a continuing application of effort or skill toward a particular project or goal (such as pest control) to decline in effectiveness after a certain level of result has been achieved.

Mainland island: An area of land on mainland New Zealand, isolated by means of fencing or geographical features, and intensively managed for the purpose of protecting and restoring habitats and ecological processes. At present most mainland islands are public conservation land managed by the Department of Conservation.

Market failure: Market failure occurs when a freely operating market does not bring about the best allocation of resources, such as costs of unsustainable practices to the environment. (*See* **Discounting**, **Economic value**)

Matauranga Maori: Maori traditional knowledge.

Matrix: The most extensive and most connected landscape element type present, which plays the dominant role in the landscape. Also a landscape element surrounding a patch (e.g. agricultural field surrounding a forest remnant)

Migratory: A description of an animal that commutes seasonally between two or more geographic locations (*See* wildlife corridor).

Monitoring: The act of measuring change in the state, number or presence of characteristics of something.

Monoculture: Industrial agricultural practice. Objective: Highest possible productivity from one crop or animal species. Management strategy is usually short-term, up to 10 years. Very dependent on fossil fuels, large machinery, a restricted range of industrial seeds, control of weeds and other life forms that might interfere with the prime objective. Applied in cropping, grazing, forestry. (compare agroforestry, ecological footprint, sustainable development, permaculture).

Monoecious: Having both male and female flowers on the same plant. (Compare dioecious, unisexual and hermaphrodite)

Mustelid: a group of mammalian predators (ferrets, stoats, weasels), introduced to control rabbits over a century ago, now a menace to native animals.

Mutualism: An interaction between two species, which benefits both. Generally applied to obligatory mutualism (orchids and fungi), sometimes used for facultative mutualism (both species benefit but neither is dependent on the relationship) (*See* symbiosis)

National policy statement: A statement of policy issued under section 52 of the Resource Management Act 1991 on matters of national importance that are relevant to achieving the purpose of the Act.

Native species: *See* Indigenous species.

Natural areas: *See* Natural habitats and ecosystems.

Natural character: The qualities of an area that taken together give it a particular recognisable character.

Natural habitats and ecosystems: Habitats and ecosystems with a dominant or significant indigenous natural character. They do not include modified areas, such as farm or forestry land, where the indigenous vegetation has largely been replaced, although these areas may still provide important habitat for indigenous species.

Naturalised: A species or other taxon originating from a region outside New Zealand, but reproducing freely and maintaining its position in competition with indigenous biota in New Zealand.

Nature Heritage Fund: (formerly Forest Heritage Fund) A contestable fund under the jurisdiction of the Minister of Conservation, established in 1990 to protect indigenous forests and other ecosystems that represent the full range of natural diversity originally present in the New Zealand landscape.

Nga Whenua Rahui: A contestable fund under the jurisdiction of the Minister of Conservation, established in 1990 to help Maori landholders to protect indigenous forest and other ecosystems in a way that is responsive to their spiritual and cultural needs.

NIWA: National Institute for Water and Atmospheric Research. NIWA is the Crown Research Institute providing a scientific basis for the sustainable management of New Zealand's atmosphere, marine and freshwater ecosystems and associated resources.

Parasitic: An organism that benefits from another organism from which it obtains its nutrients, without any benefits to the host. (compare symbiosis).

Patch: A non-linear landscape element differing from its surroundings (e.g. forest remnant in agricultural field).

Perching plant: *See* epiphyte.

Perennial: Plant with a lifespan of more than two years (compare annual).

Permaculture: Permanent agriculture is an agroforestry system coined by Bill Mollison (Australia). Permaculture design seeks to harmoniously integrate people and landscape, designing and maintaining agriculturally productive ecosystems, which have the diversity and stability of natural ecosystems. (compare agroforestry; monoculture, ecological footprint)

Pest: A plant or animal usually introduced and widely distributed in other parts of the world that out-competes one or many native life-forms, threatening native ecosystem processes and functions, a factor in continuing extinction debt. Their effect on native biota has already become apparent and measurable (*See* extinction debt, incompatible plants, invasive species).

Pioneering plant: Plants that are adapted to colonise bare land rapidly. Seeds are usually wind or bird dispersed. Plants are light demanding and part of an early succession, which usually consist of many individuals and few species. (*See* fire climax species; strategy; succession)

Phenology: Study of the periodicity, timing and abundance of leafing, flowering and fruiting in plants, often triggered by periodicities in climate.

Pollarding: Used in a grazing system instead of coppice. Trees are repeatedly cut at above browsing height. (1.5-2 m) to obtain poles for fencing, tool-handles, twigs for wickerwork, additional stock feed or firewood.

Polygamus: Having several mating partners.

Population: A group of organisms from the same species, which occupies a particular habitat or ecosystem. Its size is often limited by its territorial requirements of its individuals, the size of its habitat, ecotope and patch fragment. (compare species; pests; ecosystem/habitat fragmentation; extinction dept)

Production landscapes and seascapes: Areas, which are used predominantly for the production of primary products, for example meat, fish, fibre and timber.

Protected area: A geographically defined area that is protected primarily for nature conservation purposes or to maintain biodiversity values, using any of a range of legal mechanisms that provide long-term security of either tenure or land use purpose. It may be either publicly or privately owned.

Protected area network: A network or system of protected areas. The principal criteria for New Zealand's protected area network are:

Comprehensiveness: The degree to which the full range of ecological communities and their biological diversity are incorporated within protected areas.

Representativeness: The extent to which areas selected for inclusion in the protected area network are capable of reflecting the known biological diversity and ecological patterns and processes of the ecological community or ecosystem concerned, or the extent to which populations represent or exemplify the range of genetic diversity of a taxonomic unit.

Protected Natural Area (PNA): A legally protected area, characterised by indigenous species or ecosystems or landscape features, in which the principal purpose of management is retention of the natural state. In this Strategy, the term is used synonymously with "protected area".

Protected Natural Areas (PNA) Programme: A programme to identify and protect areas that represent the full range of indigenous biological and landscape features in New Zealand, thereby helping to maintain the distinctive character of the country. The PNA Programme is as much about the protection of biological and landscape features that are common or extensive within an ecological district as about protection of the district's unique or special features.

Realised niche: Actual range of habitats occupied when competitive effects are accounted for. A realised niche often represents sub-optimal growth conditions. (*See* fundamental niche)

Resilience: The ability of a species, population or ecosystems to respond and adapt to external environmental stresses. Resilient populations are versatile and may have many mutual links to other species within an ecosystem. Population richness is a common characteristic of resilient species. Habitat and keystone species richness and good nutrient storage and exchange capacity is a common characteristic of a resilient ecosystem. (Compare humus type – mull; ecosystem health; ecosystem processes.)

Restoration: The active intervention and management of degraded biotic communities, landforms and landscapes in order to restore biological character, ecological and physical processes and their cultural and visual qualities.

Richness: Diversity and abundance of species within an ecotope/ecosystem or of ecotopes within an ecosystem.

Riparian corridor: Natural vegetation structure that follows waterways (*See* ecotone; wildlife corridors, dispersal, migration).

Roost: A place where birds or bats meet in large numbers.

Scrub: Vegetation of woody plants dominated by shrubs and small trees 1-6 m tall covering 80 % of the ground.

Selection system is a silvicultural program of applied forest ecology, used to maintain 'uneven-aged stands' (*See* ecological silviculture, cohort, selection method, single tree-, strip-, and group-selection system).

Selection method is employed to (re-)generate uneven-aged stands, as single trees or small groups are removed. Any selection method applied to a multiple-species native afforestation site results in an uneven-aged multiple cohort stand. (*See* ecological silviculture, single tree-, strip-, and group-selection system).

Shade tolerance: Species, which are adapted to grow and persist under the canopy of other trees. Most native plants are shade-tolerant. Many juvenile plants with this adaptation are late succession species that replace more light demanding pioneer plants. (*See* strategy; fire climax species)

Shelterwood: Any harvest cutting of a more or less regular and mature crop, designed to establish a new crop under the protection of the old. Suitable for beech regeneration and conversion from exotic conifer plantations to native forestry. (compare selection system; ecological silviculture).

Shrub: Woody plant 0.2-6m tall often lacking a single main trunk.

Silviculture: The art and science of controlling the establishment, growth, composition, health, and quality of forests to meet diverse needs and values of landowners and society on a sustainable basis.

Single-tree selection system: An uneven-aged silviculture system in which mature trees are harvested individually, regenerating trees in small groups at relatively short intervals.

Species: One or more populations of individuals, linked by continuous gene flow that can, but do not necessarily interbreed with each other. Barriers to continuous gene flow and adaptation to local environmental conditions cause subspecies to evolve and may over time lead to the formation of new species. Interbreeding between different species is generally impossible or results in infertile offspring.

Strategy: Term used to describe a species' evolved adaptation to persist and compete with other species in a locality (seed dispersal, phenology, environmental tolerances; nutrient cycling/mining strategies). Ability to regenerate locally, colonise new environments and influence environmental conditions, which support that species' regeneration (compare fireclimax species; humus types; shade-tolerant species; succession).

Strip-selection system An uneven-aged stand can be created in slowly advancing strips, where opportunities are created to obtain advance reproduction and to facilitate log-extraction in difficult terrain. Progression of cutting toward the equator (SSE=>NNW) encourages regeneration of most native timber-tree species, which require protection from the elements as juveniles and are adapted to grow under partial shade (*See* selection system).

Subspecies (variety): A distinct geographical variant of a species resulting from some barrier to successful breeding with other populations of the species.

Succession: The natural progression of an ecosystem from a species-poor pioneering state towards an ecosystem with complex functions and optimal resilience for the site. (*See* silviculture, ecosystem processes)

Survey: Systematically observing, counting or measuring characteristics at a defined location over a defined period of time.

Sustainable development: Meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development respects the limited capacity of an ecosystem to absorb the impact of human activities. Many people understand that with control comes responsibility. Considering the amount of primary energy already converted for use by human society and the few wilderness places left, more people then ever are now convinced that the concept of sustainable development should include preserving the environment for other species as well as for people. (Compare adaptive management; ecological footprint; GPI; market failure; agroforestry).

Sustainable use: The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations (Convention on Biological Diversity).

Symbiosis: General term to describe situations where dissimilar organisms live together, mutualistic or parasitic. Modern use is often restricted to mutually beneficial species interactions, such as fruiting plants and seed distributing birds.

Sympathetic management: The management of land in a way that recognises or supports the needs of indigenous biodiversity. For example, exotic forests of compatible tree species can provide a habitat or wildlife corridor for native bird species and natural regeneration space for native plants.

Synergism: The result of combined factors, each of which influences a process in the same direction but which when combined give a greater effect than they would acting separately.

Taproot: Tapered main root growing directly downwards from the stems.

Taxon: (pl. taxa) A biological classification unit assigned to any rank, for example species, sub species, genus, family or order.

Temperate: Northern and southern hemisphere zones of moderate climates between the tropics/ deserts and the polar regions.

Territorial: A member of a certain animal species attempting to evict all other individuals of its species except a mate. Compare habitat, population and dispersal

Threatened species: A species or community that is vulnerable, endangered or presumed extinct. The Department of Conservation has assessed threatened species in New Zealand (using criteria relating to taxonomic distinctiveness, status of the species, threats facing the species, vulnerability of the species, and human values), and ranked them into three categories (A, B and C) of priority for conservation action.

Understorey: Layer of vegetation below a canopy of taller plants.

Uneven-aged stand contains at least three well-defined age classes, differing in age, height and diameter (*See* cohort; multiple-cohort stand; ecological silviculture)

Ungulates: Grazing or browsing mammals with an efficient digestive system.

Unisexual flower: Having either functional stamens or functional carpels (compare hermaphrodite, monoecious, dioecious)

Unwanted organism: Any organism capable of causing unwanted harm, including animal pests, weeds and diseases. (This is a wider definition than sometimes used in New Zealand, for example as in the Biosecurity Act 1993).

Value: *See* economic value.

Vascular plants: Include ferns, flowering plants and trees, but do not include mosses and liverworts.

Vertebrate: Animal with backbone; amphibians, reptiles, birds, mammals and fish. Compare Invertebrate.

Weed: A plant in the wrong place (compare pest)

Wetland: Includes permanently or intermittently wet areas, shallow water and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions.

Wildlife corridors. Linear vegetation structure that link habitats or ecosystem remnants. Important for migration, dispersal and restoration of ecosystem functions (*See* riparian corridors)

Common and Maori plant names

SCIENTIFIC NAME	MAORI NAME	OTHER COMMON NAME
Alectryon excelsus	titoki	
Alseuosmia pusilla	karapapa	
Aristotelia serrata	makomako	wineberry
Ascarina lucida	hutu	
Asplenium bulbiferum	mauku	hen & chickens fern
Asplenium flaccidum	raukatauri	drooping spleenwort
Asplenium oblongifolium		shining spleenwort
Astelia solandri	kowharawhara	perching lily
Beilschmiedia tawa	tawa	
Carpodetus seratus	putaputaweta	marble leaf
Clematis paniculata	puawananga	white clematis
Coprosma foetidissma	hupiro	stinkwood
Coprosma grandifolia	kanono	
Coprosma lucida	karamu	
Coprosma repens	taupata	
Coprosma robusta	karamu	
Coprosma rotundifolia		round leaved coprosma
Cordyline australis	ti kauka	cabbage tree
Coriaria aborea	tutu	
Corynocarpus laevigatus	karaka	
Cyathea dealbata	ponga	silver tree fern
Cyathea medullaris	mamaku	
Cyathea smithii	katote	soft tree fern
Dacrycarpus dacrydioides	kahikatea	white pine
Dacrydium cupressinum	rimu	red pine
Dicksonia fibrosa	wheki ponga	
Dicksonia squarrosa	wheki	rough tree fern
Dysoxylum spectabile	kohekohe	
Earina autumnalis	raupeka	easter orchid
Elaeocarpus dentatus	hinau	
Elaeocarpus hookerianus	pokaka	
Fuchsia excorticata	kotukutuku	tree fuchsia
Geniostoma rupestre	hangehange	
Griselinia littoralis	papauma	broadleaf
Griselinia lucida	puka	shining broadleaf
Hebe stricta	koromiko	
Hedycarya arborea	porokaiwhiri	pigeonwood
Hoheria populnea	houhere	lacebark, ribbonwood
Hoheria sextylosa	houhi ongaonga	
Ileostylus micranthus		small flowered mistletoe
Knightia excelsa	rewarewa	
Kunzea ericoides	kanuka	
Laurelia novae-zelandiae	pukatea	
Leucopogon fasciculatus	mingmingi	
Libocedrus bidwillii	kaikawaka	
Lophomyrtus bullata	ramarama	
Lophomyrtus obcordata	rohutu	
Macropiper excelsum	kawakawa	
Melicope ternata	wharangi	
Melicytus ramiflorus	mahoe	

SCIENTIFIC NAME	MAORI NAME	OTHER COMMON NAME
Metrosideros diffusa	akatea	white climbing rata
Metrosideros excelsa	pohutukawa	
Metrosideros fulgens		scarlet climbing rata
Metrosideros robusta	rata	northern rata
Microlaena avenacea		bush rice grass
Muehlenbeckia australis	pohuehue	
Myoporum laetum	ngaio	
Myrsine australis	mapou	red matipo
Myrsine divaricata	matipo	weeping matipo
Myrsine salicina	toro	
Neomyrtus pedunculata	rohutu	
Nestegis cunninghamii	maire	black maire
Nestegis lanceolata	maire	white maire
Nothofagus menziesii	tawhai	silver beech
Nothofagus solandri var cliffortioides	tawhairauriki	mountain beech
Olearia rani	heketara	
Pennantia corymbosa	kaikomako	
Peraxilla colensoi	korukoru	mistletoe
Peraxilla tetrapetala	pirirangi	mistletoe
Phormium tenax	harakeke	NZ flax
Pittosporum crassifolum	karo	
Pittosporum eugenoides	tarata	lemonwood
Pittosporum tenuifolium	kohuhu	
Pittosporum umbellatum	haekaro	
Planchonella costata	tawapou	
Podocarpus hallii	totara	halls totara
Podocarpus totara	totara	lowland totara
Polystichum vestitum		prickly shield fern
Prumnopitys ferruginea	miro	brown pine
Prumnopitys taxifolia	matai	black pine
Pseudopanax arboreus	puahou	fivefinger
Pseudopanax colensoi		mountain fivefinger
Pseudopanax crassifolius	horoeka	lancewood
Pseudopanax edgerleyi	raukawa	
Pseudopanax simplex	haumakaroa	seven finger
Pseudowintera axillaris	horopito	lowland pepper tree
Pseudowintera colorata	horopito	alpine pepper tree
Quintinia serrata	tawherowhero	
Rhopalostylis sapida	nikau	
Ripogonum scandens	karewao/pirita	supplejack
Rubus cissoides	tataramoa	bush lawyer
Schefflera digitata	pate	
Sophora species	kowhai	
Streblus heterophylla	turepo	small leaved milk tree
Syzygium maire	maire tawaki	swamp maire
Tradescantia fluminencis		wandering jew/willie
Uncinia species		hook grass
Vitex lucens	puriri	
Weinmannia racemosa	kamahi	
Weinmannia silvicola	towai	

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Phenology tables

Table 15: Emergent storey flowering and fruiting times in relation to native birds' annual life cycle

BUSH STOREY'S SYMBIOTIC (KEY) PLANTS		BIRDS' LIFE CYCLES											
		Survival				Breeding				Migration			
Common names	***Botanical names***	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
EMERGENT STOREY													
Kahikatea*	*Dacrycarpus dacrydiodes*	F			F	F	F	F	F	F	F	F	F
Rimu*	*Dacrydium cupressinum*									F	F	F	
Rewarewa	*Knightia excelsa*					N	N	N	N				
Pohutukawa+	*Metrosideros excelsa*							N	N				
Northern rata+	*Metrosideros robusta*						N	N	N				
Southern rata+	*Metrosideros umbellatum*						N	N	N	N	N		
Totara*+	*Podocarpus totara*	F	F					F	F	F	F	F	F
Miro*	*Prumnopitys ferruginea*	F	F	F	F						F	F	F
Matai*	*Prumnopitys taxifolia*							F	F	F	F	F	F
CLIMBERS AND EPIPHYTES													
Mistletoe+	*Alepis flavida*							N	NF	NF	F	F	F
Fragrant astelia*	*Astelia fragrans*					N	N	F	F	F	F	F	F
Astelia*+; Kowharawhara	*Astelia solandri*	NF	F	F	F	NF	NF	NF	NF	NF	NF	NF	NF
Shore astelia*	*Astelia banksii*	NF	F	F	F	F	F	F	F	F	NF	NF	NF
Kahakaha*	*Collospermum hastatum*	F	F	F				N	N	N	F	F	F
Kiekie*	*Freycinetia banksii*									F	F	F	
Puka, Shining Broadleaf*+	*Griselinia lucida*	F	F				F	F	F	F	F	F	F
Mistletoe+	*Ileostylus micranthus*					N	N	N	F	F	F	F	
White rata vines+	*Metrosideros diffusa; M. colensoi;*				N	N	N	N					
Small-leaved rata	*M. perforata*							N	N	N			
Red rata vines+	*Metrosideros fulgens; M. carminea*	N								N	N	N	N
Kohia passion vine*+	*Passiflora tetranda*	F	F	F							F	F	F
Mistletoe+	*Peraxilla tetrapetala; P colensoi*					N	N	N	N	F	F		
Supplejack+	*Ripogonum scandens*	F	F	F	F	F	F	F	F	F	F	F	F

* = Male and female sexes on different plants.
Several individuals are needed to ensure fruiting
\+ = Indicator plants for animal-pest presence.

F = Fruit
N = Nectar

Table 16: Canopy and sub canopy storeys' flowering and fruiting times in relation to native birds' annual life cycle

BUSH STOREY'S KEY PLANTS		BIRDS' LIFE CYCLES											
Common Names	***Botanical Plant Names***	Survival				Breeding				Migration			
CANOPY AND SUBCANOPY		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Titoki*+	*Alectryon excelsus*					F	F	F	F	F			
Taraire	*Beilschmiedia tarairi*						F	F	F	F	F		
Tawa+	*Beilschmiedia tawa*							F	F	F	F	F	F
Putaputaweta	*Carpodetus serratus*		F	F	F	F	F	F	F	F			
Forest cabbage tree	*Cordyline banksii*						N	N	N	F	F	F	
Karaka	*Corynocarpus laevigatus*								F	F	F	F	F
Kahikatea*	*Dacrycarpus dacrydiodes*	F			F	F	F	F	F	F	F	F	F
Kohekohe*+	*Dysoxylum spectabile*	NF	N	F	F						N	N	N
Hinau+	*Elaeocarpus dentatus*									F	F	F	F
Pokaka+	*Elaeocarpus hookerianus*						F	F	F	F	F	F	
Kotukutuku* -+	*Fuchsia excorticata*			N	N	N	NF	NF	NF	NF	F	F	F
Broadleaf*	*Griselinia littoralis*	F	F	F								F	F
Pigeonwood*	*Hedycarya arborea*				N	N	NF	NF	F	F	F	F	
Tawari	*Ixerba brexioides*	F	F				N	N	N	N		F	F
Rewarewa	*Knightia excelsa*					N	N	N	N				
Mangeao*	*Litsea calicaris*			N	N	NF	F	F	F				
Ramarama	*Lophomyrtus bullata*						N	N	NF	NF	F	F	
Rohutu	*Lophomyrtus obcordata*							N	N	N	F	F	F
Mahoe*+	*Melicytus ramiflorus*	F								F	F	F	F
Mountain mahoe*	*Melicytus lanceolatus*		F	F	F	F	F	F	F	F			
Pohutukawa+	*Metrosideros excelsa*							N	N				
Northern rata+	*Metrosideros robusta*							N	N	N			
Mapou*	*Myrsine australis*					F	F	F	F	F	F	F	
Black maire*	*Nestegis cunninghamii*					F	F	F	F	F	F	F	
White maire*	*Nestegis lanceolata*						F	F	F	F	F	F	F
Towai, Milk tree*+	*Paratrophis banksii*									F	F	F	
Turepo*+	*Paratrophis microphylla*						F	F	F	F	F		
Kaikomako*	*Pennantia corymbosa*									F	F	F	F
Hall's Totara*+	*Podocarpus hallii*											F	F
Totara*+	*Podocarpus totara*	F	F		F		F		F	F	F	F	F
Miro*	*Prumnopitys ferruginea*	F	F	F	F						F	F	F
Matai*	*Prumnopitys taxifolia*							F	F	F	F	F	F
Fivefinger*+	*Pseudopanax arboreus*	F	NF	NF	NF	F	F	F	F	F	F	F	F
Mountain fivefinger*+	*Pseudopanax colensoi*	N	N	N	N	N				F	F	F	N
Raukawa*+	*Pseudopanax edgerleyi*	F	F								F	F	F
Fivefinger*+	*Pseudopanax laetus*		N	N	N					F	F	F	F
Haumakaroa*	*Pseudopanax simplex*	F	F	F									F
Pepper tree Kawakawa	*Pseudowintera axillaris*	F				F	F	F	F	F	F	F	F
Nikau *+	*Rhopalostylis sapida*							NF	NF	NF	F	F	F
Swamp Maire	*Syzygium maire*	F	F	F				NF	NF	NF	NF	F	F
Milk tree	*Streblus banksii*									F	F	F	
Turepo	*Streblus heterophyllus*						F	F	F	F	F		
Puriri	*Vitex lucens*	FN	FN	FN	FN	FN	F	F	F	F	F	F	FN
Kamahi+	*Weinmannia racemosa*					N	N	N	N				

* = Male and female sexes on different plants. Several individuals are needed to ensure fruiting
+ = Indicator plants for animal-pest presence.

F = Fruit
N = Nectar

Table 17: Understorey and regenerating storeys' flowering and fruiting times in relation to native birds' annual life cycle

BUSH STOREY'S KEY PLANTS		BIRDS' LIFE CYCLES											
Common Names	***Botanical Plant Names***	Survival				Breeding				Migration			
UNDERSTOREY AND REGENERATION		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Karapapa	*Alseuosmia pusilla*	N	N	N	N	N	N			F	F	N	N
Hutu*	*Ascarina lucida*					F	F	F	F				
Stinkwood*+	*Coprosma foetidissima*	F										F	F
Kanono*+	*Coprosma grandifolia*	F	F							F	F	F	F
Karamu*+	*Coprosma lucida*								F	F	F	F	
Mingimingi (soft)*.	*Coprosma propinqua*										F	F	F
Twiggy coprosma*	*Coprosma rhamnoides*									F	F	F	
Round-leaved C.*	*Coprosma rotundifolia*									F	F	F	F
Wavy-leaved C.*	*Coprosma tenuifolia*											F	F
Long-leaved Korokio	*Corokia buddleioides*								F	F	F	F	
Wire Netting Bush	*Corokia cotoneaster*								F	F	F	F	F
Karaka	*Corynocarpus laevigatus*									F	F	F	
Mingimingi (soft)*	*Cyathodes fasciculata*				F	F	F	F	F	F	F	F	F
Mingimingi prickly*	*Cyathodes juniperina*	F	F	F	F	F	F	F	F	F	F	F	F
NZ blueberry	*Dianella nigra*							F	F	F	F		
Kotukutuku* Tree -+	*Fuchsia excorticata*			N	N	N	NF	NF	NF	NF	F	F	F
Tawari	*Ixerba brexioides*	F	F				N	N	N	N		F	F
Kawakawa*	*Macropiper excelsum*	F	F	F	F	F	F	F	F	F	F	F	F
Narrow L. Mahoe*	*Melicytus lanceolatus*	N	F	F	F	F	F	F	F	F			
Mahoe*+	*Melicytus ramiflorus*	F								F	F	F	F
Shrubby rata+	*Metrodideros parkinsonii*						N	N	N				
Mida*	*Mida salicifolia*						F	F	F	F	F		
Mapou*	*Myrsine australis*					F	F	F	F	F	F	F	F
Weeping Mapou*	*Myrsine divaricata*	F	F								F	F	F
Toro*	*Myrsine salicina*				F	F	F	F	F	F	F	F	F
Ground cover nertera	*Nertera depressa*								F	F	F	F	F
Mairehau	*Phebalium nudum*					N	N	N					
Heart-leaved kohuhu	*Pittosporum obcordatum*					N	N	F	F	F			
Haekaro+	*Pittosporum umbellatum*				N	N	NF	NF	NF	F	F	F	F
Fivefinger*+	*Pseudopanax arboreus*	F	NF	NF	NF	F	F	F	F	F	F	F	F
Lancewood, Horoeka*	*Pseudopanax crassifolius*	F	F	F	F						F	F	F
Haumakaroa*+	*Pseudopanax simplex*	F	F	F									F
Horopito/pepper tree	*Pseudowintera axillaris/colorata*	F	F					F	F	F	F	F	F
Tawherowhero	*Quintinia serrata*					N	N						
Taurepo,	*Rhabdothamnus solandri*	N	N	N	N	N	N	N	N	N	N	N	N
Pate+	*Schefflera digitata*	F	F	F	F								F
Poroporo	*Solanum laciniatum*	F			N	N	NF	NF	NF	NF	NF	NF	F
Toru	*Toronia toru*					N	N	F	F	F			

* = Male and female sexes on different plants. Several individuals are needed to ensure fruiting
\+ = Indicator plants for animal-pest presence.

F = Fruit
N = Nectar

Table 18: Forest edge flowering and fruiting times in relation to native birds' annual life cycle

BUSH STOREY'S KEY PLANTS		BIRDS' LIFE CYCLES											
		Survival				Breeding				Migration			
Common names	***Botanical names***												
FOREST EDGE AND SCRUB		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Wineberry*+	*Aristotelia serrata*								F	F	F	F	F
Rengarenga	*Arthropodium cirratum*						N	N					
Native broom	*Carmichaelia sp.*					N	N	N	N	N	N		
Putaputaweta	*Carpodetus serratus*		F	F	F	F	F	F	F	F			
Kakabeak	*Clianthus puniceus*					N	N						
Taupata*+ (coastal)	*Coprosma repens*							F	F	F			
Karamu*+	*Coprosma robusta*	F	F	F						F	F	F	F
Cabbage tree	*Cordyline australis*				N	N	N	N	F	F	F		
Mountain cabbage tree	*Cordyline indivisa*							N	N	F	F	F	F
Tutu	*Coriaria arborea*						F	F	F	F	F	F	
Korokio	*Corokia cotoneaster*								F	F	F	F	F
Whau	*Entelea arborescens*				N	N	N	N					
Kotukutuku* -+	*Fuchsia excorticata*			N	N	N	NF	NF	NF	NF	F	F	F
Creeping fuchsia+	*Fuchsia procumbens*					N	N	N	NF	F	F		
Broadleaf*	*Griselinia littoralis*	F	F	F								F	F
Koromiko	*Hebe parviflora*							N	N	N	N		
Willow koromiko	*Hebe stricta*							N	N	N	N	N	
Narrow-leaved lacebark+	*Hoheria angustifolia*							N	N	N	N		
Lacebark; Houhere+	*Hoheria populnea; H. sextylosa*	N									N	N	N
Kanuka	*Kunzea ericoides*					N	N	N	N				
Manuka	*Leptospermum scoparium*				N	N	N	N	N	N			
Coastal porcupine pl.*	*Melicytus obovatus*	F	F	F	F	F	F	F			F	F	F
Mahoe*+	*Melicytus ramiflorus*	F								F	F	F	F
Ngaio	*Myoporum laetum*		F	F			N	N		F	F	N	N
Mapou*	*Myrsine australis*					F	F	F	F	F	F	F	F
Toro*	*Myrsine salicina*				F	F	F	F	F	F	F	F	F
Rohutu	*Neomyrtus pedunculata*									F	F	F	F
Coastal maire	*Nestegis apetala*								F	F	F	F	F
Common trea daisy	*Olearia arborescens*						N	N	N				
Streamside tree daisy	*Olearia cheesemanii*			N	N	N	N	N	N				
Akiraho	*Olearia paniculata*									N	N	N	N
Heketara	*Olearia rani*			N	N	N							
Kaikomako*	*Pennantia corymbosa*									F	F	F	F
Flax (mountain)	*Phormium cookianum*						N	N	N				
Flax (lowland)	*Phormium tenax*						N	N	N				
Karo*	*Pittosporum crassifolium*	F	F	F	NF	NF	NF	N				F	F
Tarata*	*Pittosporum eugenoides*	F	F			N	N				F	F	F
Kohuhu*	*Pittosporum tenuifolium*				N	N	N			F	F	F	F
Tawapou	*Pouteria (syn Planchonella) costata*								F	F	F	F	
Fivefinger*+	*Pseudopanax arboreus*	F	NF	NF	NF	F	F	F	F	F	F	F	F
Raukawa*+	*Pseudopanax edgerleyi*	F	F								F	F	F
Lancewood, Horoeka*	*Pseudopanax crassifolius*	F	F	F	F						F	F	F
Fivefinger*+	*Pseudopanax laetus*		N	N	N					F	F	F	F
Horopito/pepper tree	*Pseudowintera axillaris/colorata*	F	F					F	F	F	F	F	F
Central N I. kowhai	*Sophora godleyi*					N	N	N					
Common kowhai	*Sophora microphylla*			N	N	N							
East coast kowhai	*Sophora tetraptera*				N	N	N						

* = Male and female sexes on different plants. Several individuals are needed to ensure fruiting
\+ = Indicator plants for animal-pest presence.

F = Fruit
N = Nectar

Table 19: Score sheet 1 of 8 – bush size and shape

Bush vitality visual assessment	Site name .... Location .... Date		
(A) Native forest size and shape	Select one category only. One score from (A.1; A.2 or A.3).	Criteria score	Your score
(A.1) Size – over 25ha	**Explanation**		
Average width over 100m	Large habitat area, compact shape – even perimeter, large forest interior compared to edge forest. Site can support a full range of native plants and animals found in the region.	16	
Average width 20 to 100m	Large habitat area, less compact shape, likely to be long and thin in shape or convoluted perimeter, some forest interior, considerable edge forest.	12	
Average width under 20m	Large habitat area, very long and narrow shape, likely to be forest along a river margin, no forest interior, all edge forest. Site can support good populations of native regeneration and shrubs and may sustain original populations of the more common native plants and animals found in the region.	6	
(A.2) Size 5 to 25ha	**Explanation**		
Average width over 100m	Moderate sized habitat area, compact shape, even perimeter or long and narrow for large-sized sites, substantial forest interior, some edge forest. Site can support good populations of the more common native plants and animals found in the region.	14	
Average width 20 to 100m	Moderate sized habitat area, less compact shape, likely to be long and thin in shape or convoluted perimeter, some forest interior, considerable edge forest.	10	
Average width under 20m	Moderate sized habitat area, long and narrow shape, likely to be forest along a river margin, no forest interior, all edge forest. Site can support good populations of native regeneration and shrubs and may sustain original populations.	4	
(A.3) Size – less than 5ha	**Explanation**		
Average width over 100m	Small habitat area, very compact shape, some forest interior but size means considerable edge forest. Site can support moderately good populations of the more common native plants and animals found in the region.	12	
Average width 20 to 100m	Small habitat area, less compact shape, likely to be long and thin in shape or convoluted perimeter, mostly edge forest. Site can support more common native plants and animals found in the region but in lower abundance.	8	
Average width under 20m	Small habitat area, narrow strip, likely to be forest along a river margin, no forest interior, all edge forest. Site can support good populations of native regeneration and shrubs and may sustain fragile original populations.	2	
A) Shape and size score	Excellent Good Fair	16 12 8	

Table 20: Score sheet 2 of 8 – bush connectivity			
Bush vitality visual assessment Score categories B.1 to B.3	**Site name** .... **Location** .... **Date**		
(B) Native forest habitat connections	**Your comments**	Criteria score	Your score
(B.1) Native forest habitat present within 2km of site			
A few large sites (over 25 ha: 1/4 of 1km^2 grid on 1:50,000 scale topographic map).		6	
Many small sites (more than 3 sites 1-25ha)		5	
A few small sites (less than 3 sites 1-25ha)		4	
Compatible exotic plants scattered		3	
No native forest habitat present within 2km of site		0	
(B.2) Native forest habitat present between 2 and 5km from site			
A few large sites (over 25ha).		5	
Many small sites (more than 5 sites 1-25ha)		3	
A few small sites (less than 5 sites 1-25ha)		2	
Compatible exotic plants scattered		2	
No native forest habitat present between 2-5km distant		0	
(B.3) Native forest habitat present between 5 and 10km from site			
	Exchange barred for many native species:		
A few large sites (over 25ha)		3	
Many small sites (more than 10 sites 1-25ha)		2	
A few small sites (less than 10 sites 1-25ha)		1	
Compatible exotic plants scattered		1	
No native forest habitat present between 5-10km distant		0	
B) Native forest habitat connections score	Excellent Good Fair	14 10 6	

You may check and tick this category wherever it applies. It is independent of the other scoring system.

(B.4) Bush-wetland connectivity	Upstream	Downstream	**Native fish access**	Inflow	Outflow
Fenced. Native bush or wetland plant corridors on stream banks to next wetland site			No impediments to fish migration. Natural permanent water flow.		
Fenced. Mainly exotic plant corridors on stream banks to next wetland site			Seasonal migration barriers. Temporarily obstructed flow, dam; weir		
Unfenced. No corridors on stream banks to next wetland site (exotic grass only)			Permanent migration barriers to fish Culvert perched (>10cm); dam; weir		

Its purpose: consider restoring forest wetland connectivity when developing your bush management strategy

Table 21: Score sheet 3 of 8 – emergent storey		
Forest structure Score categories C.1 to C.6	**Site name**	
	Location	**Date** ....

(C.1) EMERGENT COVER		Criteria score	Your score
More than 20%	Obvious emergent tier with more than 20% or 20 trees present.	10	
Less than 20%	Sparse emergent trees with less than 20% and more than 10 trees present.	6	
None	No emergent trees present.	0	

RESOURCES (1) Record key plants found and (2) Note Fruiting/Buds/Flowering: Many (+) or Few (-)			
(C.2) Winter-early spring food supply	**Your comments**	Criteria score	Your score
No species	None	0	
1–2 species; Many individual plants[34]	Fair	2	
3 species or more; Many individual plants	Good	3	
(C.3) Spring-summer food supply			
No species	None	0	
1–2 species; Many individual plants	Fair	1	
3 species or more; Many individual plants	Good	2	
(C.4) Autumn migration food supply			
No species	None	0	
1–2 species; Many individual plants	Fair	1	
3 species or more; Many individual plants	Good	2	

EXOTIC PESTS	***Score threats to the emergent layer***	Criteria score	Your score
(C.5) Pest animals	Comprehensive animal pest control effectively applied (5% possum trap catch, rodent and mustelid/cat control). Score 1 for effective control of each pest class: Predators or omnivores.	2	
	No control. Predator, omnivore sign (Leaf browse, bark bitemarks)	0	
(C.6) Pest plants	No incompatible or listed plant pests. Score 1 for **absence** or **effective control** of each pest class: climbers; trees.	2	
	No control. Each pest class present (including fire, cold or shade-tolerant trees)	0	

(C) EMERGENT LAYER SCORE		Criteria score	Your score
	Excellent	20	
	Good	16	
	Fair	14	

34 Distinguish 2 abundance levels for each species:
- 'Many' stands for more than 10 trees of each species;
- 'Few' stands for less than 10 plants of each species

You may score an intermediate number if you find only 'few' plants of a kind. Take note of it.
Remedy as you implement your bush management strategy.

Table 22: Score sheet 4 of 8 – canopy storey	
Forest structure Score categories D.1 to D.6	**Site name** .... **Location** .... **Date** ....

(D.1) CANOPY AND SUBCANOPY COVER		Criteria score	Your score
Canopy cover greater than 90%.	Will have a more or less continuous canopy cover.	4	
Subcanopy cover greater than 40%		4	
Canopy cover 50–90%.	Disturbance to canopy with some gaps but limited in extent.	2	
Subcanopy cover 10–40%.	Subcanopy with some gaps but limited in extent.	2	
Canopy cover less than 50%.	Canopy highly disturbed with obvious gaps, sometimes large in extent.	1	
Subcanopy cover less than 10%	Subcanopy with major gaps; past grazing pressure.	1	

RESOURCES (1) Record key plants found and (2) Note **Fr**uiting/**B**uds/**Fl**owering: Many (+) or Few (-)

(D.2) Winter-early spring food supply	**Your comments**	Criteria score	Your score
No species	None	0	
1–3 species; Many individual plants[35]	Fair	2	
4 species or more; Many individual plants	Good	3	
(D.3) Spring-summer food supply			
No species	None	0	
1–3 species; Many individual plants	Fair	2	
4 species or more; Many individual plants	Good	3	
(D.4) Autumn migration food supply			
No species	None	0	
1–3 species; Many individual plants	Fair	1	
4 species or more; Many individual plants	Good	2	

(D.5) Pest animals Your Regional Council can help with tracking tunnels, possum trap catch monitoring and pest control support.		
Comprehensive animal pest control effectively applied (5% possumtrap catch, rodent and mustelid/cat control). Score 1 for effective control of each pest class: predators or omnivores	2	
No control. Predator, omnivore sign (Leaf browse, bark bite marks)	0	
(D.6) Pest plants Your Regional Council can help with plant pest control advice and support.		
No incompatible or listed plant pests. Score 1 for **absence or effective control** of each pest class: climbers; shrubs; trees.	3	
No control. Each pest class present (including fire, cold or shade-tolerant trees)	0	

(D) CANOPY AND SUBCANOPY SCORE	Excellent Good Fair	18 15 10	

35 Distinguish 2 abundance levels for each species:
- 'Many' stands for more than 10 trees of each species;
- 'Few' stands for less than 10 plants of each species

You may score an intermediate number if your find only "few" plants of a kind. Take note of it. Remedy as you implement your bush management strategy.

Table 23: Score sheet 5 of 8 – understorey and regeneration

Forest structure Score categories E.1 to E.6	Site name .... Location .... Date ....

(E.1) UNDERSTOREY AND REGENERATION COVER		Criteria score	Your score
Shrub tier greater than 40% cover. Seedlings common or abundant	Understorey intact, shrub and ground layer vegetation in good abundance including good numbers of seedlings.	6	
Shrub tier 10–40% cover. Some seedlings present.	Understorey partially intact, sparser shrubs, some seedling regeneration, moderate levels of vegetation browse may be visible.	3	
Shrub tier less than 10% cover. Seedlings few or absent.	Understorey highly disturbed, little vegetation present, few or no seedlings present, high levels of vegetation browse may be visible.	1	

RESOURCES (1) Record key plants found and (2) Note **Fr**uiting/**B**uds/**Fl**owering: Many (+) or Few (-)

(E.2) Winter-early spring food supply	Your comments	Criteria score	Your score
No species	None	0	
1–3 species; Many individual plants[36]	Fair	2	
4 species or more; Many individual plants	Good	3	
(E.3) Spring-summer food supply			
No species	None	0	
1–3 species; Many individual plants	Fair	1	
4 species or more; Many individual plants	Good	2	
(E.4) Autumn migration food supply			
No species	None	0	
1–3 species; Many individual plants	Fair	1	
4 species or more; Many individual plants	Good	2	

(E.5) Stock access to bush	Criteria score	Your score
Never, or over 10 years ago. Score 1 for every 2 years of protection from browsing or sheltering stock.	5	
Signs of access within past 2 years	0	
(E.6) Pest animals Your Regional Council can help with tracking tunnels, possum trap catch monitoring and pest control support.		
Comprehensive animal pest control effectively applied (5% possum trap catch). Score 1 for effective control of each pest class: predators, omnivores or browsers	3	
No control: Signs of predators, omnivores and/or browsers.	0	
(E.7) Pest plants Your Regional Council can help with plant pest control advice and support.		
No incompatible or listed plant pests. Score 1 for **absence or effective control** of each pest class: climbers and groundcover; shrubs; trees.	3	
No control. Each pest class present (including shade-tolerant or incompatible juvenile plants)	0	

(E) UNDERSTOREY/REGENERATION SCORE			
	Excellent	22	
	Good	18	
	Fair	12	

36 Distinguish 2 abundance levels for each species:
- 'Many' stands for more than 10 trees of each species;
- 'Few' stands for less than 10 plants of each species

You may score an intermediate number if your find only "few" plants of a kind. Take note of it. Remedy as you implement your bush management strategy.

Table 24: Score sheet 5 of 8 – forest edge and shrubs

Forest structure Score categories F.1 to F.6	Site name .... Location .... Date ....

(F.1) EDGE AND REGENERATING SHRUB		Criteria score	Your score
Edge or regenerating shrub entirely native	Best regenerative potential for the full range of native species.	6	
Native plants (>50%) and compatible exotics.	Advanced native regeneration, compatible exotic plants (such as tree-lucerne) near edge.	5	
Compatible exotic (>50%) and native plants.	Native bush and regeneration sheltered by compatible exotic shrubs and trees (tree lucerne, poplars etc.).	4	
Incompatible exotic ***shelterbelt*** protecting native bush from prevailing wind.	Native bush and regeneration sheltered by a row of pines, macrocarpa, eucalypts etc.	1	
Incompatible exotic ***plantations*** around bush.	Adverse conditions for bush patch's future. Sparse native regeneration on pine litter (acidic humus).	0	

RESOURCES (1) Record key plants found and (2) Note **Fr**uiting/**B**uds/**Fl**owering: Many (+) or Few (-)

(F.2) Winter-early spring food supply	Your comments		Criteria score	Your score
No species		None	0	
1–3 species; Many individual plants[37]		Fair	2	
4 species or more; Many individual plants		Good	3	
(F.3) Spring-summer food supply				
No species		None	0	
1–3 species; Many individual plants		Fair	1	
4 species or more; Many individual plants		Good	2	
(F.4) Autumn migration food supply				
No species		None	0	
1–3 species; Many individual plants		Fair	1	
4 species or more; Many individual plants		Good	2	

(F.5) Stock control/fencing	Criteria score	Your score
Fence in good condition around entire perimeter	3	
Partly. Stock access occasionally possible	0	
(F.6) Pest animals Your Regional Council can help with tracking tunnels, possum trap catch monitoring and pest control support.		
Comprehensive animal pest control effectively applied (5% possum trap catch). Score 1 for effective control of each animal pest class: predators, omnivores or browsers	3	
No control: Signs of predators, omnivores and/or browsers.	0	
(F.7) Pest plants Your Regional Council can help with plant pest control advice and support.		
No incompatible or listed plant pests. Score 1 for **absence or effective control** of each pest class: climbers and groundcover; shrubs; trees.	3	
No control. Each pest class present (including fire, cold or shade-tolerant trees of any age)	0	

(F) EDGE AND REGENERATING SHRUB SCORE			
	Excellent Good Fair	22 17 13	

37 Distinguish 2 abundance levels for each species:
- "Many" stands for more than 10 trees of each species;
- "Few" stands for less than 10 plants of each species

You may score an intermediate number if your find only "few" plants of a kind. Take note of it.
Remedy as you implement your bush management strategy.

 Please photocopy for use. Additional copies of these tables and score sheets are available from www.horizons.govt.nz

Table 25: Score sheet 7 of 8 – native animals

Native animals	Site name ....
	Location .... Date ....

Your comments

(G.1) Key animals sustaining bush vitality	Record numbers seen and where observed	Top score	Your score
Bellbird		3	
Kereru		3	
Tui		3	
Stitchbird		3	
Silvereye		3	
Forest geckos and skinks		2	
Beech scale insect (sooty mould)		3	
Native bees		2	
Hoverflies		2	
Bumble bees		1	

(G.2) Animals indicating habitat intactness	Record numbers seen and where observed	Top score	Your score
Tomtit		2	
Robin		2	
Rifleman		2	
Parakeet		2	
Kaka		2	
Kiwi		2	
Kokako		2	
Whitehead		1	
Fernbird		1	
Stick insect		1	
Weta		1	
Giant land snail		1	
Peripatus		1	

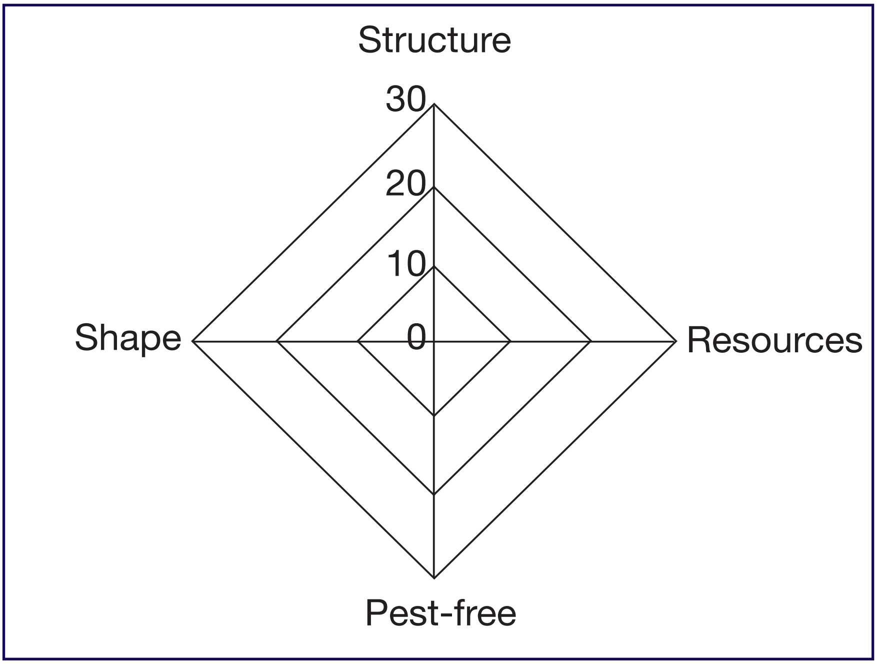
(G.1) Keystone animal score	Excellent	25	
(G.2) Indicator animal score	Excellent	20	

Table 26: Score sheet 8 of 8 – summary scores for each category

Summary scores for the entire bush site	Site Name: .... Location: .... Date: ....

Category		Your comments:	Top score	Your score
Shape	**A) Shape and Size score**		16	
Shape	**B) Connectivity score**		14	
Shape	*Spatial integrity score*	Sum of (A + B.1 + B.2 + B.3)	30	
Structure	**C.1) Emergent cover score**		10	
Structure	**D.1) Canopy and subcanopy cover score**		8	
Structure	**E.1) Understorey/regeneration cover score**		6	
Structure	**F.1) Edge and regenerating shrub score**		6	
Structure	*Forest structure integrity score*	Sum of forest storeys and edge integrity	30	
Resources	**Winter and early spring resources Sum of: (C.2 + D.2 + E.2 + F.2)**		12	
Resources	**Spring and summer resources Sum of: (C.3 + D.3 + E.3 + F.3)**		10	
Resources	**Autumn migration resources Sum of: (C.4 + D.4 + E.4 + F.4)**		8	
Resources	*Total resource availability score*	Yearly food supply continuity	30	
Pests	**Animal pest control score Sum of: (C.5 + D.5 + E.5 + E.6 + F.5 + F.6)**		18	
Pests	**Plant pest absence score Sum of: (C.6 + D.6 + E.7 + F.7)**		12	
Pests	*Total pest pressure score*	Freedom from plant and animal pests. Sum of pest absence	30	
Bush Vitality	**BUSH DIAMOND SCORE** Sum of spatial and structural integrity; resource availability and pest pressure scores	Excellent Good over Fair over	4x30 4x25 4x20	
Bush Vitality	**G.1) Key animal score**		25	
Bush Vitality	**G.2) Indicator animal score**		20	
Bush Vitality	*Total native animal score*	Compare with: **'Bush diamond score'**	**45**	
Bush Vitality	**BUSH VITALITY SCORE**	Excellent over Good over Fair over	150 120 90	

Table 27: Summary score charts



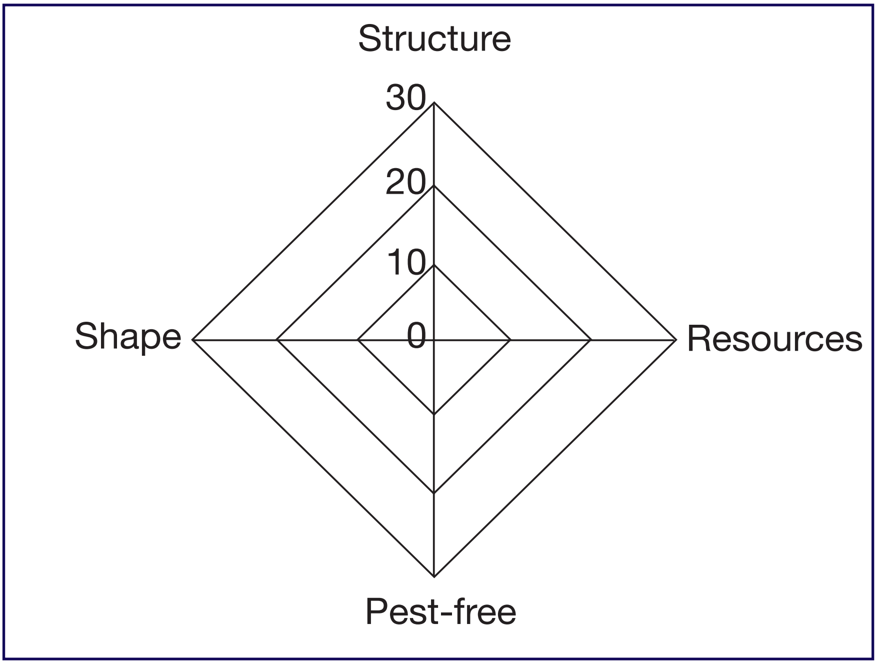


Table 28: Bush diagnosis

Element	Strengths	Weaknesses
Spatial integrity		
Forest structurea		
Food resources		
Pests		
Element	Oportunities	Threats
Spatial integrity		
Forest structure		
Food resources		
Pests		